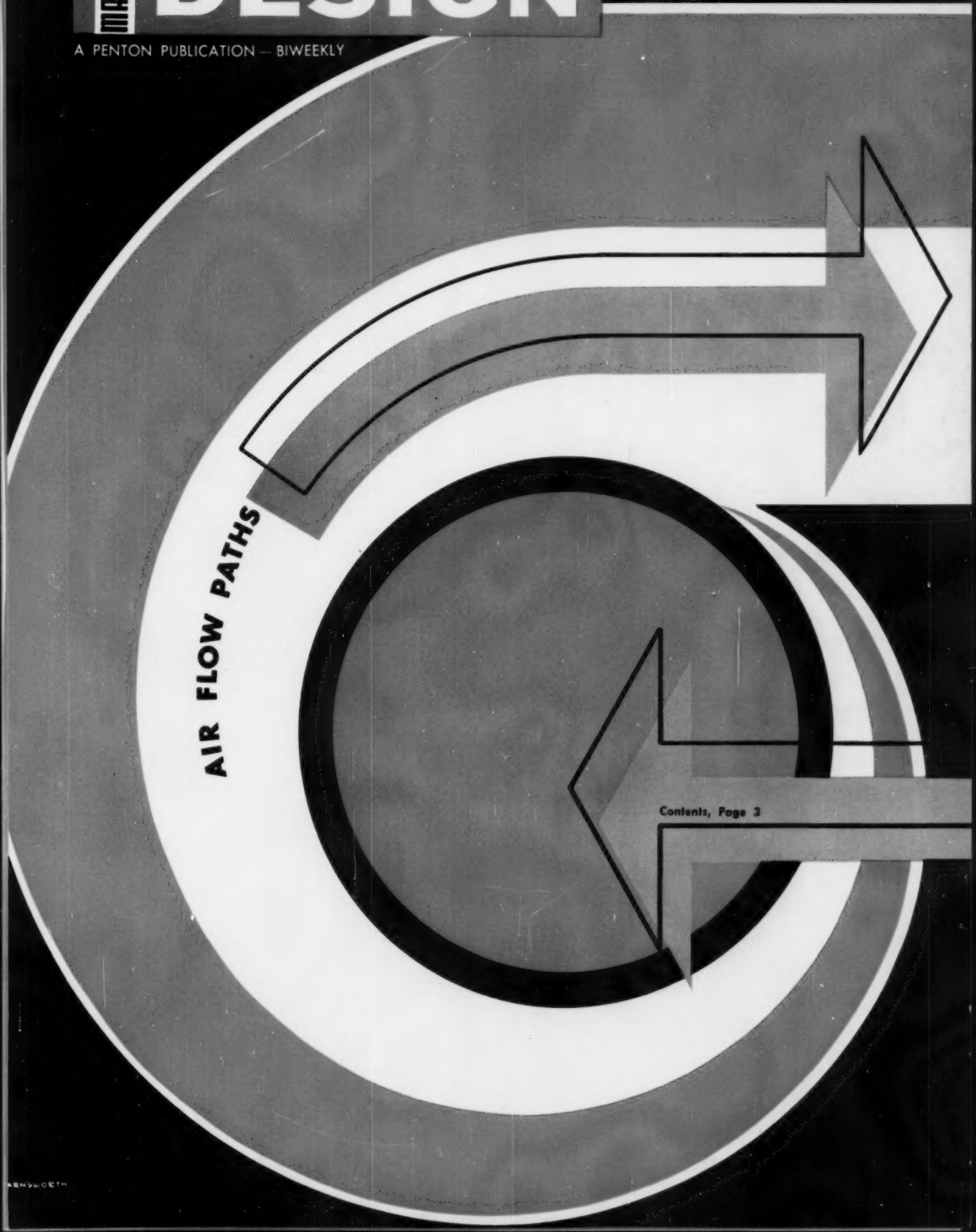
FEBRUARY 18, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



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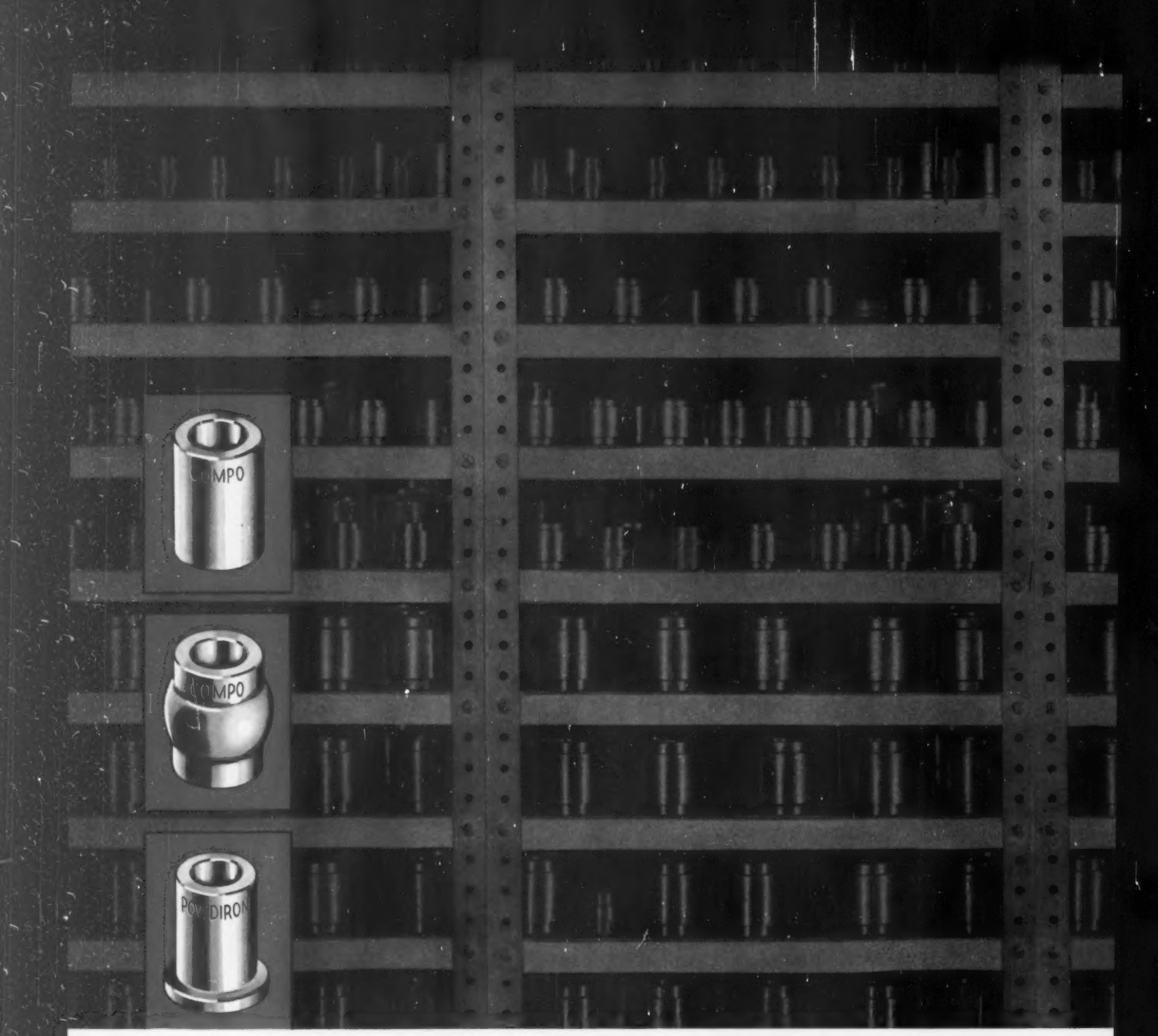

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Plants at Bound Brook, N.J. and Sturgis, Mich.

MOTOR USER'S CASE HISTORY

"We've used BODINE MOTORS for 38 years!"

. . HEDMAN COMPANY

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. . C. W. Johnson, vice-president, Hedman Company

Here's Hedman's latest application of a Bodine Motor!

This is a Keypunch Protector. It consists of a Hedman Royal Keyboard Check Protector with a built-in IBM code key punch mechanism. As shown in the photo to the right, it automatically punches the correct amount into tab card checks, receipts, and register copies at the same time it imprints the amount. Hedman engineers selected the Bodine type VCF-12 motor because they need a small, quiet motor that will last a long time and give trouble-free service.

Bulletin tells story of late model business machine motor.

Here's the story of Bodine's latest model business machine motor . . the FSE-23. It's only 2 5/16" high . . weighs only 1 pound 11 ounces . . and delivers plenty of power. It fits into minimum space because it's rectangular in shape. Ask for your copy of Technical Bulletin #1034. Bodine Electric Company, 2508 West Bradley Place, Chicago 18, Illinois.

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For further information, see your A-L sales engineer or write for the new technical booklet, "AM 350 and AM 355," **Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.**

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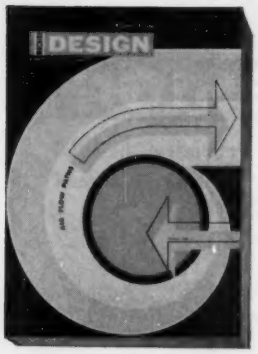

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Prescription for Progress: More Imaginative Research

Schools, Societies Called Upon To Stamp Out Conservatism, Stop "Hole-Plugging" Research

WORCESTER, MASS.—A speed-up in scientific and technological progress would occur if conditions for research and development were more stimulating. And the stimulation should be directed at young researchers.

These conclusions were reached at a conference on "Research Goals" held at Worcester Polytechnic Institute and attended by leading scientists, educators, and industrial researchers. The conference was sponsored by the National Science Foundation and held in co-operation with 15 scientific and engineering societies.

"Progress in science and technology has made its greatest strides as a consequence of a relatively few individuals whose originality of thought and brilliance of achievement have blazed new trails leading to discoveries of major consequence," reads the report of the conference committee. "But modern research also requires the amassing of enormous amounts of detailed scientific and technological knowledge. Because of this, it is easy for research people to become preoccupied with goals of relatively small dimensions which . . . have little promise of leading to significant discovery."

Suggestions to Twig-Benders

Seeking to jostle young researchers out of the rut of scientific conservatism, a resolutions committee formed at the conference had some recommendations for educators and engineering societies.

To provide an atmosphere that will nourish young creative minds, colleges and universities can:

• Develop educational programs which require the student to exercise a high degree of originality and independence of thought. The student should be challenged with creative experiences throughout his entire educational experience.

• Bring talented youth into stimullative personal association with leading scientists and engineers.

• Encourage more venturesome goals for doctoral research. The generally accepted requirement that a doctorate student must complete a specified research goal causes students to resort to "hole-plugging" research. A student should not necessarily be penalized if he fails to reach a distant objective.

• Develop institutional policies which provide an encouraging environment for venturesome research. This starts with faculty members who themselves are creative.

• Develop closer liaison between college, industrial, and governmental research organizations.

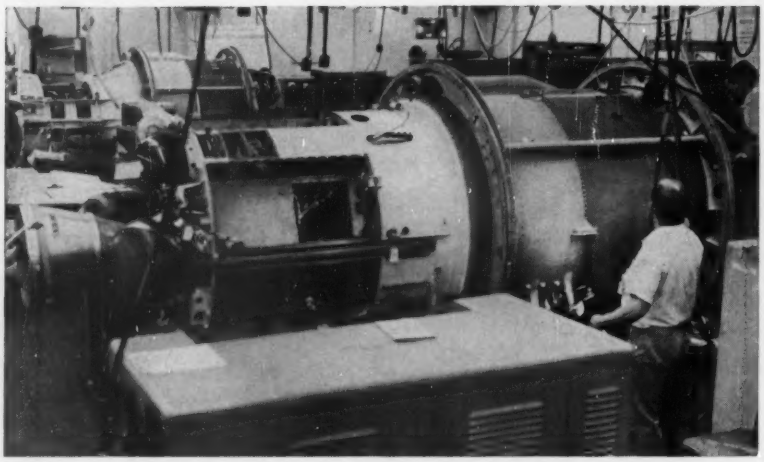
• Encourage undergraduate and graduate students who have novel, creative ideas to pursue the development of these ideas and help them obtain financial support.

Scientific and engineering societies can also support the cause of neo-research if they:

• Establish more effective practices which will increase the attendance and participation of talented young members at meetings.

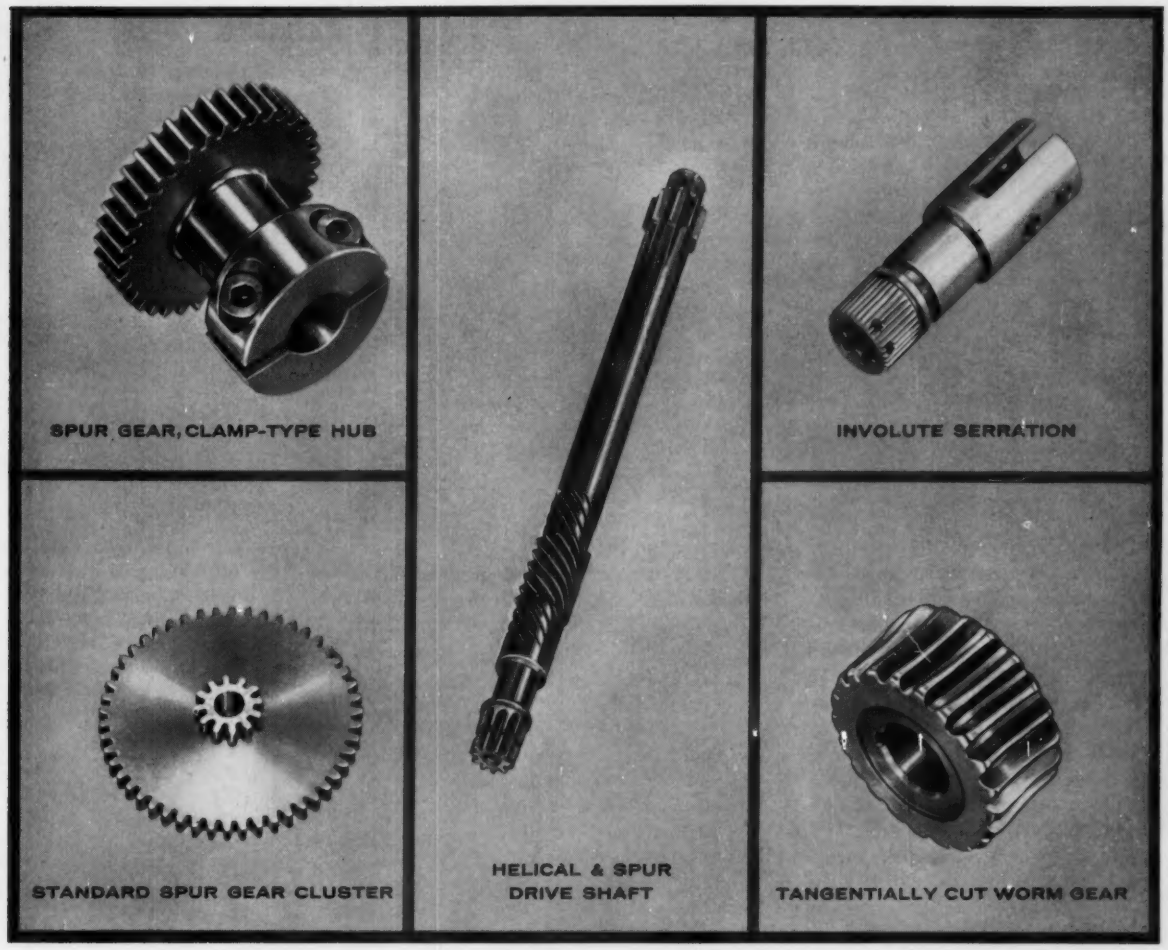
• Encourage the presentation and publication of philosophical papers which look to the future of science and technology.

• Develop comprehensive programs



Orbit Jumper: The Restartable Satellite

Increased agility in space exploration is promised by restartable versions of the Lockheed Agena satellite vehicle. The "production line" space package, without its restartable feature, has already been used in a half dozen successful Discoverer firings. It's now scheduled to be the workhorse in the Air Force Samos (photographic) and Midas (infrared) advanced reconnaissance satellite systems. Agena's ability to restart provides two big advantages: 1. Heavier payloads can be orbited by the same vehicle. 2. Circular orbits can easily be established—a necessity in the case of Samos and Midas. Here's how Agena will operate: Its engine will be shut down after orbital velocity is achieved at the perigee (low point) of an elliptical orbit. When the vehicle reaches the orbit apogee, the engine will be restarted and the thrust used to achieve a circular orbit. This coasting technique will permit a heavier payload to be placed in a higher circular orbit with a minimum energy expenditure.



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Progress Demands a New Outlook

"The pace of progress of our whole emerging pattern of scientific and technological development depends largely upon our ability to bring forth research people who can leap ahead to the goals of larger ultimate consequence," writes Arthur Bronwell, chairman of the "Research Goals" Conference, in his introduction to the conference committee's report. However, rigidities of a highly structured society block this kind of originality of thought and independence of effort. Because most of our research effort is necessarily concerned with small extensions of existing knowledge in well-traveled fields, it holds virtually no promise of leading to revolutionary discoveries.

"Can we now find ways of creating those conditions which will give more of our talented youth a new lease on the future—a new zeal for the pursuit of distant goals that might lead to highly significant discoveries in science and technology? Those who participated in this conference believe we can. However, this can be achieved only if we are willing to abandon orthodoxies and discard outworn traditions."

for digesting research knowledge.

- Establish society meetings to develop more effective interchange of ideas between scientists and engineers in research areas of broad mutual interest.
- Establish free forums at engineering society conventions where any member may make a short presentation of his creative work.
- Actively promote and encourage financial support for research.
- Help older society members recognize the contribution which they can make by stimulating creativity among young people.

The report stressed the need for financial support for colleges and universities: "The educational values of research in the colleges cannot be underestimated; they are vital, imperative, and essential to the bringing forth of creative minds." Final recommendation of the conference committee is that scientific and engineering societies take the initiative in bringing together leaders in education, industry, and government to study the problems of large-scale research.

Biggest Small Car

Middle-size Comet rolls into Ford's line-up between the Falcon and the standard-size Ford. First of the bigger small cars, it offers a smoother ride than a compact, as well as "luxury" touches in styling, trim, and interior appointments. The Comet is 2 to 3 ft shorter than the three largest-selling standard cars and stretches 14 in. beyond its cousin, the Falcon. Wheelbase of the station wagon is 109.5 in.; length, 191.8 in. Wheelbase of the sedan is 114 in., 4.5 in. longer than a Falcon. Both sedans and wagons are available in two and four-door models; all have six-cylinder engines which reportedly get 25 mpg. Price of the four-door wagon: $2365.

Engine Specifications

Bore and stroke (in.)	3.5 x 2.5
Displacement (cu in.)	144.3
Compression ratio	8.7 to 1
Power, max (bhp)	90 @ 4200
Torque, max (lb-ft)	138 @ 2000

Topics

National Engineers' Week, sponsored by the National Society of Professional Engineers, is Feb. 21-27. Theme for this year's observance is "Engineering's Great Challenge . . . the 1960's."

• • •

Half a suit of armor is better than none, and it's also less cumbersome than a whole suit. A recently patented reversible shield against blasts (atomic or otherwise) can be carried telescoped and pulled out when needed. The wearer affixes the shield to protect his back if he is fleeing the site of the blast, or if he elects to stay put, he places the shield on frontwards and stands against a wall or lies on the ground.

• • •

Disarmament would have been a snap many centuries ago if plowshare processing equipment supplied by Lindberg Engineering Co. had been available. A new automated line at the John Deere Plow Works has a capacity of 700 plowshares an hour, and quality and uniformity are said to be improved.

• • •

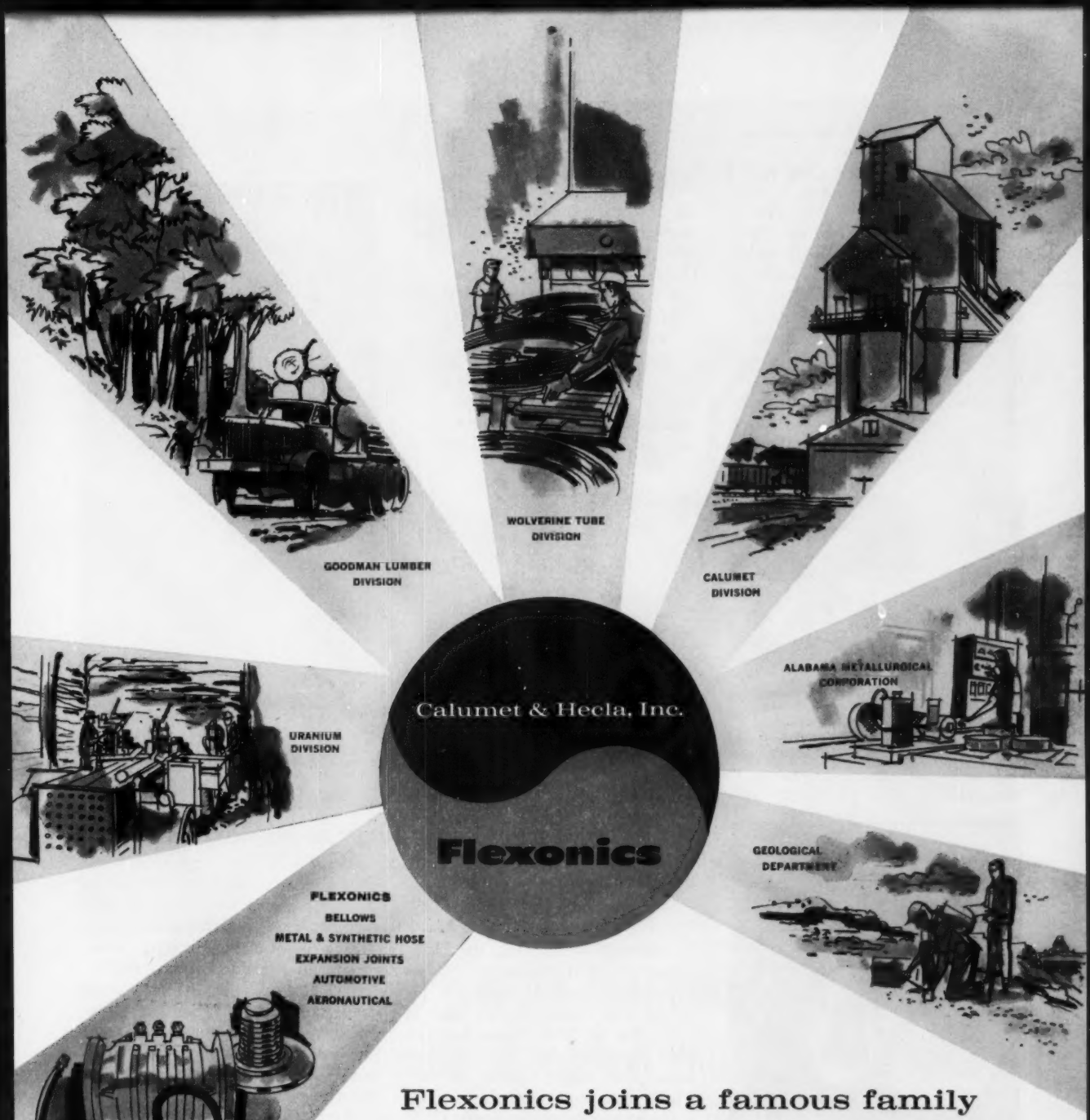
Operating a real train with no more of a crew than that needed for the model that runs under the Christmas tree is a practical possibility, according to W. A. Robison, design engineer of Union Switch & Signal Div. of Westinghouse Air Brake Co. Decisions on routing, starting, acceleration, deceleration, and stopping of a crewless train would be made by computers along the right-of-way. A dispatcher (human, presumably) would supervise movements from a monitoring panel.

• • •

Fried rice, tested and proved in Oriental diets, is a versatile industrial material as well. New processes for combustion of rice hull ash, developed by Ontario Research Foundation, Toronto, have produced a refractory material usable at temperatures to 3000 F, a thermal insulator, abrasive materials, and a plastic filler.

• • •

Pungent packaging has been made possible through the development of scented polyethylene film. "Clean linen" aroma for fresh laundry packages; perfume for women's clothing and accessories; cedar, pine, and spruce for men's sport clothes; chocolate and spearmint for candy-box wrappings; and a cookie aroma for cookie and cracker-box wrappers all are available from Fragrance Process Co. Inc. Five fruit flavors, potato, and onion smells are also brewing.



Flexonics joins a famous family

. . . to bring you better products and services

Flexonics Corporation's new affiliation with Calumet & Hecla, Inc., marks another important forward step.

Over its fifty-year history, Flexonics has become a major factor in the precision forming of thin metals—in the manufacture of metal hose, metallic bellows, expansion joints, hydraulic hose assemblies, automotive parts, aircraft and missile ducting systems—virtually everything for combined motion and fluid flow.

Calumet & Hecla now brings its broad industrial base to Flexonics technology. To industry, this means that new research and development facilities, new production capabilities, will soon be bringing you even better Flexonics products, an even wider range of Flexonics services.

The entire Flexonics organization is looking forward to serving you better . . . in more ways.

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a subsidiary of **Calumet & Hecla, Inc.**

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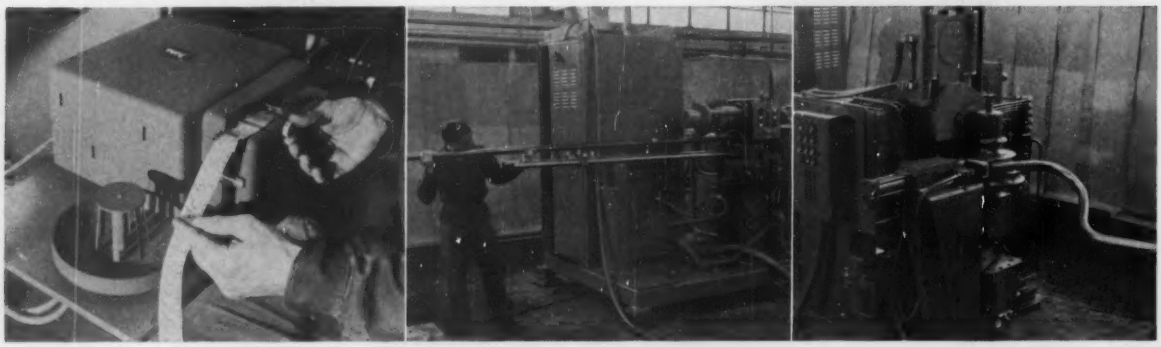
Tape Straightens Out the Tailpipe Tangle

Most perishable parts on today's automobiles are mufflers and tailpipes . . . and some 750 different tailpipe configurations are concealed under the nation's 70 million cars and trucks. For the big parts distributor, all this is a mixed blessing . . . he sells lots of tailpipes, but he also has a tremendous amount of space tied up in unmanageable stacks of crooked tubing. Three major companies—General Electric Co., Baldwin-Lima-Hamilton Corp., and Nu-Era Corp.—have apparently relieved the pipe jam by combining their talents in machine design. The result: A tape-controlled tailpipe bender which permits all 750 different tailpipe configurations to be "stored" on tape (18 in. of tape per pipe) instead of in a warehouse. Now, all the operator needs is a big neat stack of straight pipe; the machine does the rest in about two minutes. Nu-Era Corp. will market the bender.



Scant Scandium Stockpile Reaches One Pound

Two discs, each about the size of a hockey puck, and together weighing 1 lb, comprise the largest quantity of scandium ever produced. This rare metal interests the Air Force because its density compares to that of aluminum, but its 1550 C melting point is approximately two and one-half times that of aluminum. Union Carbide Metals Co., division of Union Carbide Corp., produced the two discs and will study scandium's physical, chemical, and mechanical properties under Air Force contract.

The Atom Chasm: Bigger than the Missile Gap?

Costs, Failures Hold Up Progress, Congress Looks for the Missing kw

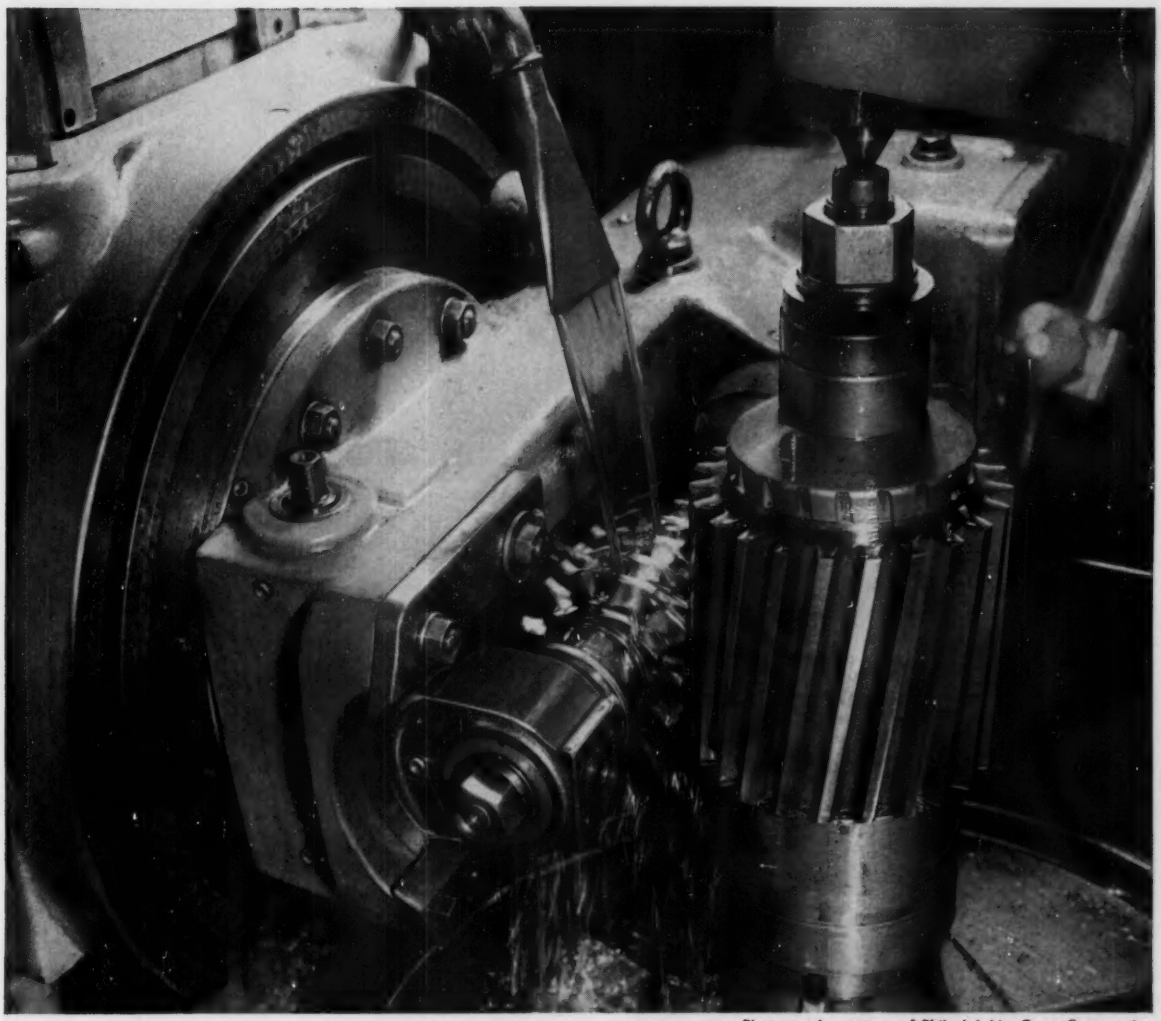
WASHINGTON—"In 1953, the U. S. held undisputed leadership in atomic-power technology, and we retained this leadership as late as 1955. But by 1958, Russia had not only closed the gap, but in some areas had moved ahead of us." These statements were the basis of a recent attack on the entire U. S. atomic-power program by Congressman Chet Holifield (Cal.). Speaking before a Workshop Meeting of the Electric Consumer Information Committee, the Congressman painted a discouraging picture of past accomplishments and future objectives in the U. S. atom effort.

All Quiet at Shippingport

"As of this date not one watt of civilian power is being generated in the U. S. by atomic reactors, except possibly by the small Oak Ridge HRE experiment. The Shippingport reactor, our first and largest central-station plant, has been shut down since October for planned replacement of fuel elements and will not be in operation until spring; AEC's experimental boiling water reactor at Argonne is under modification and will not be in operation until late this year, and the Commission's sodium reactor experiment at Santa Susana has been shut down since last October for correction of a fuel element failure."

Reactor plants under construction are also having their troubles, according to the Congressman. First and largest privately financed commercial plant in the country, the Dresden station, has recently run into technical problems—fuel-element cladding and control-rod failures. The next largest commercially financed plant, Consolidated Edison's Indian Point installation, has already experienced an increase in the estimated cost from $55 million to $100 million, and this may be only the beginning.

The public and cooperative atomic energy plants report similar difficulties. The first cooperative public



Photograph courtesy of Philadelphia Gear Corporation

Aristoloy LEADED* provides freer machining with no sacrifice of tensile strength at PHILADELPHIA GEAR

The very qualities that make good gear steels—high-tensile strength, extreme wear and load resistance—make them difficult and expensive to machine.

Philadelphia Gear Corporation solved this problem by switching to Copperweld leaded steel.

This helical gear, for example, is being cut from a bar of Aristoloy 4140 leaded which has been heat treated to a 300 to 320 Brinell Hardness. The lead addition permits an increase in spindle RPM, increased hob feed and improvement in the number of pieces per tool grind.

But none of the desirable strength qualities required of a gear steel are reduced by the minute lead particles. They act as built-in lubricant and in no way affect the physical properties.

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Circle 409 on Page 19

atomic power proposal, submitted to the Commission in 1955, is still not complete. The completion date of 1959 has slipped to 1962, and the original cost estimate has gone up from approximately $25 million to $50 million.

Of the seven public and cooperative atomic proposals submitted to the Commission in 1955 and 1956, only two are presently being pursued. These are the Piqua and the Elk River projects, neither of which is complete. The estimated cost of both projects has approximately doubled, and the original estimated completion dates have been extended considerably.

A Medal for the Navy

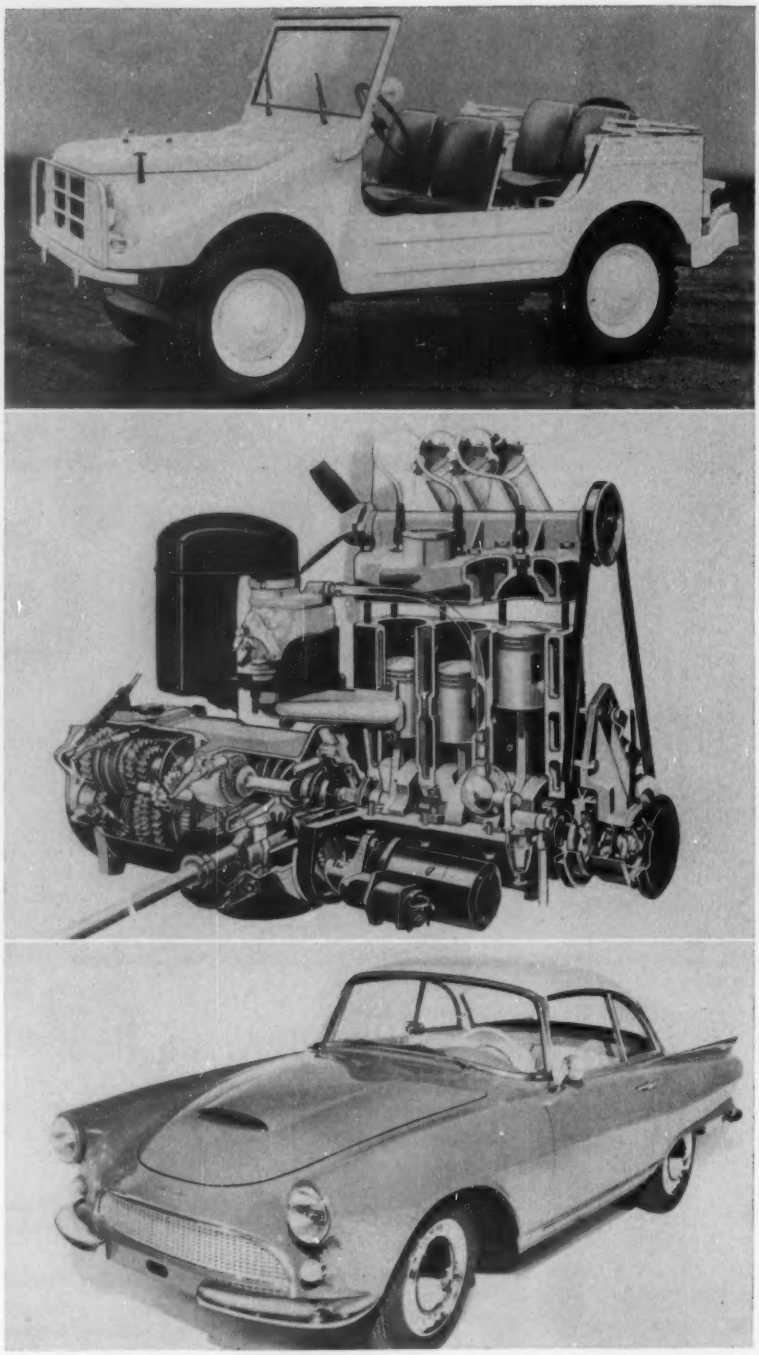
According to Mr. Holifield, the only bright spot in our power reactor program is our Naval Reactor program "where reactors at this moment are performing a job which cannot be equalled by any other energy source. Admiral Rickover has not placed his nuclear submarine program in accordance with what he thought the Russians might be doing in nuclear submarine development. He has pressed ahead as rapidly as possible, and as a result the security of the U. S. is greatly bolstered by the possession of this unique and powerful weapon."

The Congressman thinks that the same policy should apply in the field of atomic-power development. "If not, we may forever be predicting that economic power will be here in 10 years—as we have been predicting every year since 1953."

Solution?

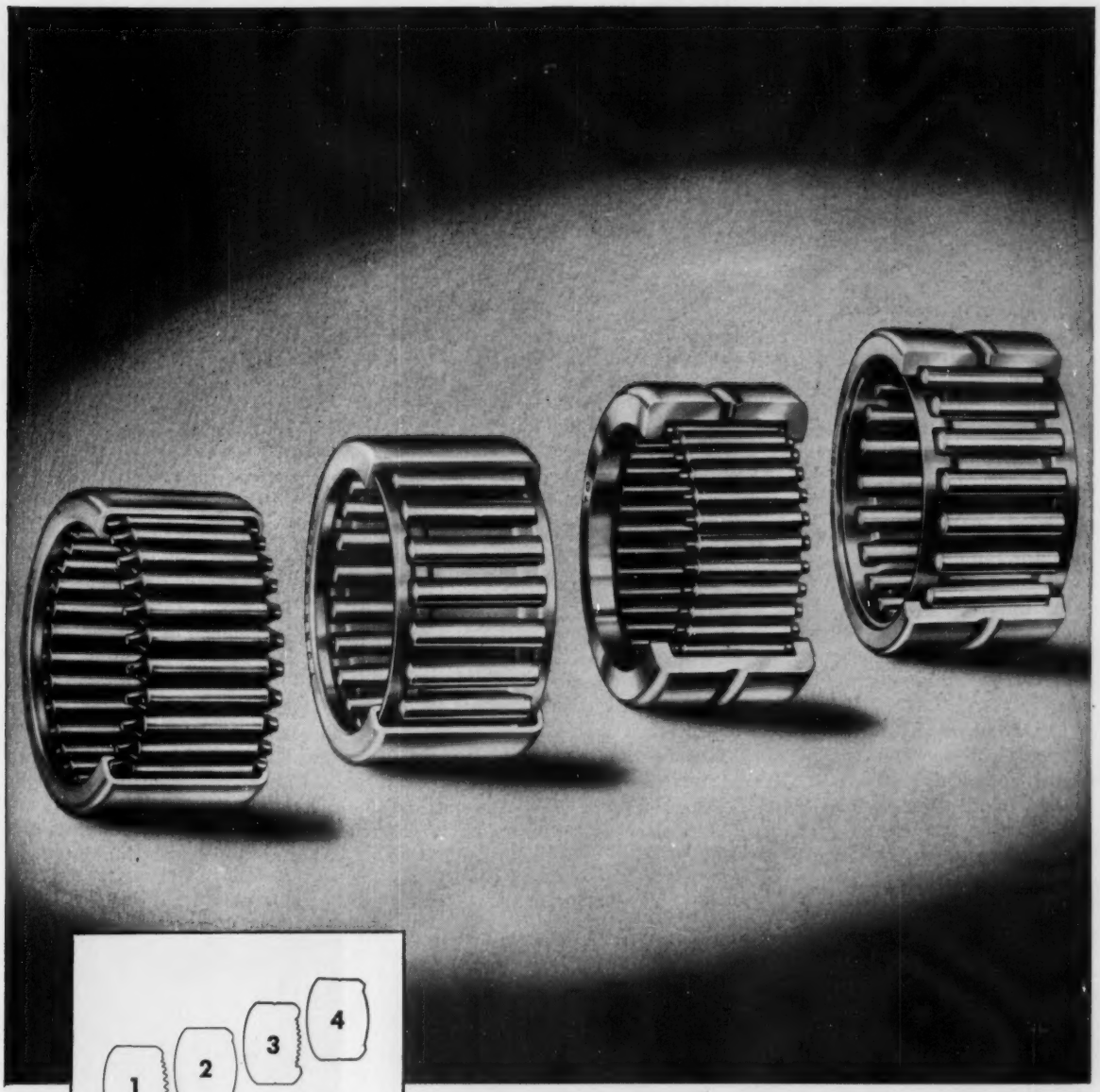
Mr. Holifield is critical of AEC's policy of emphasizing only three basic reactor concepts (pressurized water, boiling water, and organic cooled and moderated). "If we confine our major bets to only three basic concepts, we may save money in the short run, but if we have guessed wrong, the cutbacks being made by AEC will prove to be extremely costly." He also suggests that instead of making more predictions, the U. S. should start construction "by 1965 on 300,000 kw boiling water and organic plants which should produce power at costs competitively in high-fuel-cost areas of the country. Presumably, these could be in operation before 1969.

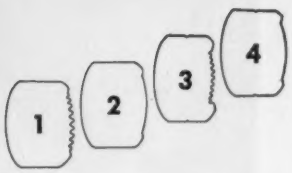
Three Cylinders for Work or Play



Four-wheel driven, by a three-cylinder engine, the DKW Bronco (top) will carry its full payload up a 50-deg. grade. The Jeeplike German import has eight speeds forward, two in reverse, can wade through water to a depth of 20 in. The same engine (center) that powers the Bronco also performs in the new sport coupe (below). The streamlined two-seater has an over-all length of 164 in. and is just 51 in. in height. (Volkswagen: 160.2 in; 59.1 in.) The coupe is front-wheel driven, gets 35 mpg, and has a top speed of 87 mph.

Engine Specifications	Bronco	Sport Coupe
Bore & Stroke (in.)	2.9 × 3	2.9 × 3
Displacement (cu in.)	59.7	59.7
Compression ratio	7.25 to 1	8 to 1
Power, max (bhp)	50 @ 4500	62 @ 4500
Speed, max (mph)	60	87





Torrington Drawn Cup Needle Bearing . . . for maximum radial capacity in minimum cross section . . . positioned by press fit—snap rings or shoulders unnecessary . . . runs directly on hardened shaft . . . most compact, light weight, economical.

Torrington Drawn Cup Roller Bearing . . . for higher speeds or long pregreased life . . . thin section race for simple press fit . . . runs directly on hardened shafts . . . unit construction for easy assembly . . . shaft-riding retainer.

Torrington Heavy Duty Needle Bearing . . . for use with thin section or split housing where extreme impact loads require heavy outer race . . . maximum shock resistance . . . full roller complement . . . unit construction.

Torrington Heavy Duty Roller Bearing . . . for combination of high speed, long pregreased life or shock resistance . . . roller stability provided by end-guiding . . . flange-riding retainer . . . unit design.

All of these types of bearings are available with inner races.

Only Torrington Makes All Four!

Torrington developed the Needle Bearing and its specialized variations. This breadth of experience assures impartial engineering recommendations based on specific application requirements. You can rely on Torrington to recommend the most compact and economical design compatible with operating conditions and performance requirements. Call on your Torrington representative for help in applying the right bearing in the right place. **The Torrington Company, Torrington, Conn.—and South Bend 21, Indiana.**

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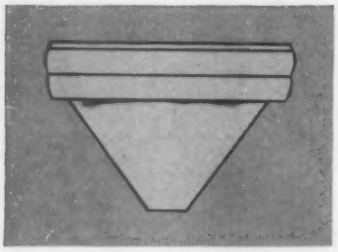
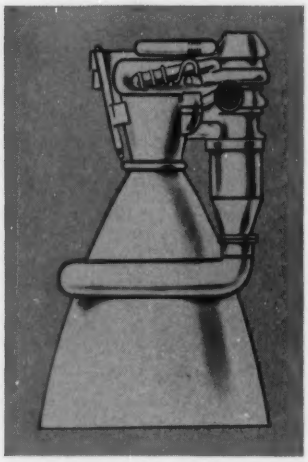
First of a New Generation: The Plug-Nozzle Rocket Engine





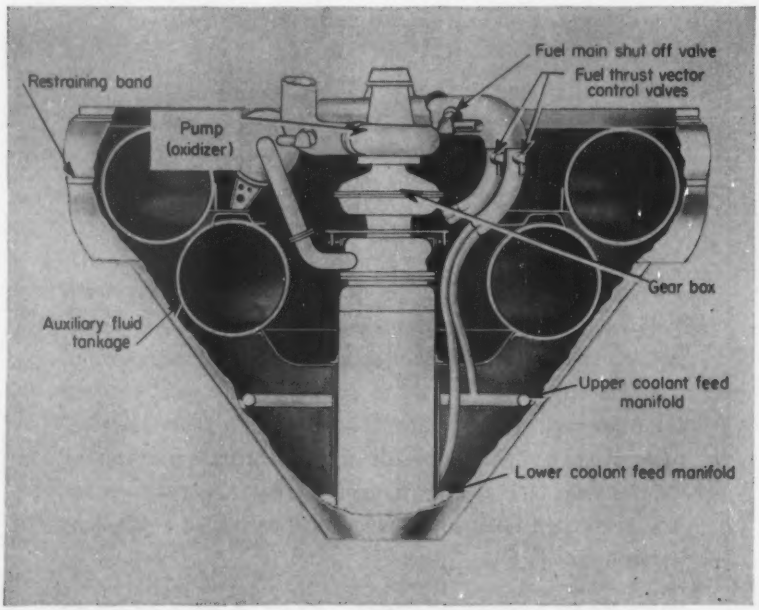
New ideas in propulsion may provide space vehicles with a first-stage engine like the one on the left, instead of the one on the right. Both are drawn to the same scale; both would deliver the same thrust.

A NEW TYPE rocket engine may close the gap between American and Soviet powerplants and win back years in the space race. Called a plug-nozzle engine, it may lead to lightweight and compact multimillion pound thrust systems in the near future.

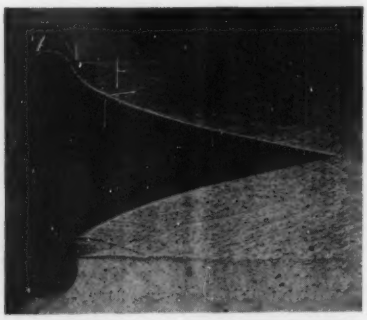
Conceived by General Electric, the plug-nozzle engine is now undergoing feasibility studies at GE's rocket engine test station, Malta, N. Y. Tests are conducted under an NASA contract.

Once basic engine development is completed, the design can be readily scaled to provide any desired thrust, say GE engineers. With older engine configurations, propulsion system designers have been faced with combustion phenomena which have defied scaling. Severe oscillatory modes show up when a conventional engine is increased in size. Scaling problems have been attacked with cut-and-try methods, but all meaningful testing is conducted with full-thrust combustors.

Not so with the new engine, however. It uses cellular combustion chambers which can be designed and tested on a small scale and then assembled to achieve desired thrust levels. Combustor size is small enough to suppress adverse combustion phenomena. Basically an assembled configuration, the engine differs from clustered systems now under development in that its cells are designed specifically for a single integrated power package. It forms a segmented annular com-



One scheme calls for the plug to house the hardware. Turbine, gear box, auxiliary fuel tank, and other engine components could all be compactly located in the plug. Turbine exhaust could be brought out through the center of the nozzle, adding its thrust to that of the engine.



Shadowgraph of the plug-nozzle flow field shows that a large portion of the gas expansion occurs externally. Gases are confined only by the plug surface; the outer jet surface, a free boundary, is influenced by velocity and pressure of the ambient air. As the ratio of combustion-chamber pressure to ambient pressure increases, the outer jet surface tends to fan out away from the plug. The jet cross-sectional area at the plug tip (the effective nozzle exit area) adjusts itself according to altitude, increasing rocket efficiency. High efficiency occurs at low altitudes, making the engine especially suitable as a first-stage rocket.

bustor about the base of the plug.

Diameter of the combustor and diameter of the plug could both be increased should a higher-thrust engine be needed. In this case, the number of cells about the plug's circumference would be increased, but combustion volume in each cell would remain unchanged.

The multiple-cell configuration will permit in-flight trajectory correction by the control of combustion pressure in various cells. Thrust would therefore be varied aerodynamically rather than mechanically. Mounting between engine and frame would be rigid, and gimbaling mechanisms and structures for stress redistribution would no longer be necessary.

Engineering Grads Outnumbered by Recruiters

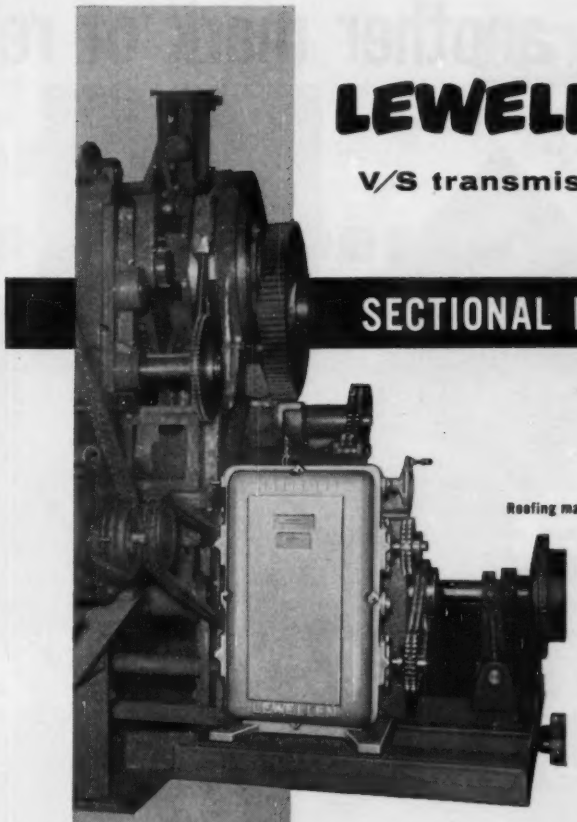
More Jobs Offered, But Columbia Graduates Few

NEW YORK—The engineering class of '60 may find a record-breaking number of job opportunities available—at least if the happenings at Columbia University prove typical throughout the country. Size of the graduating class is down and demand for graduates is up, says John A. Bornemann, placement director.

Graduating electrical and mechanical engineers are outnumbered almost 4 to 1 by the number of companies competing for their services. Aircraft and missile makers are "extremely active" in their recruiting, but other industries are also competing.

All indications point to considerably more interest in both bachelor and master candidates. Already 25 per cent more companies have scheduled interviews than at the same time last year. Competition is so keen that some companies have already cancelled because of lack of response.

Starting salaries should rise over '59 figures by at least two or three per cent—and maybe more, says Bornemann. There is the possibility of significantly greater increases in some fields where the demand far exceeds the supply.



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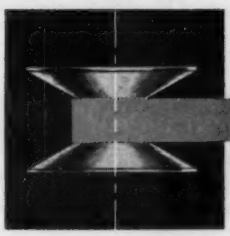

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414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
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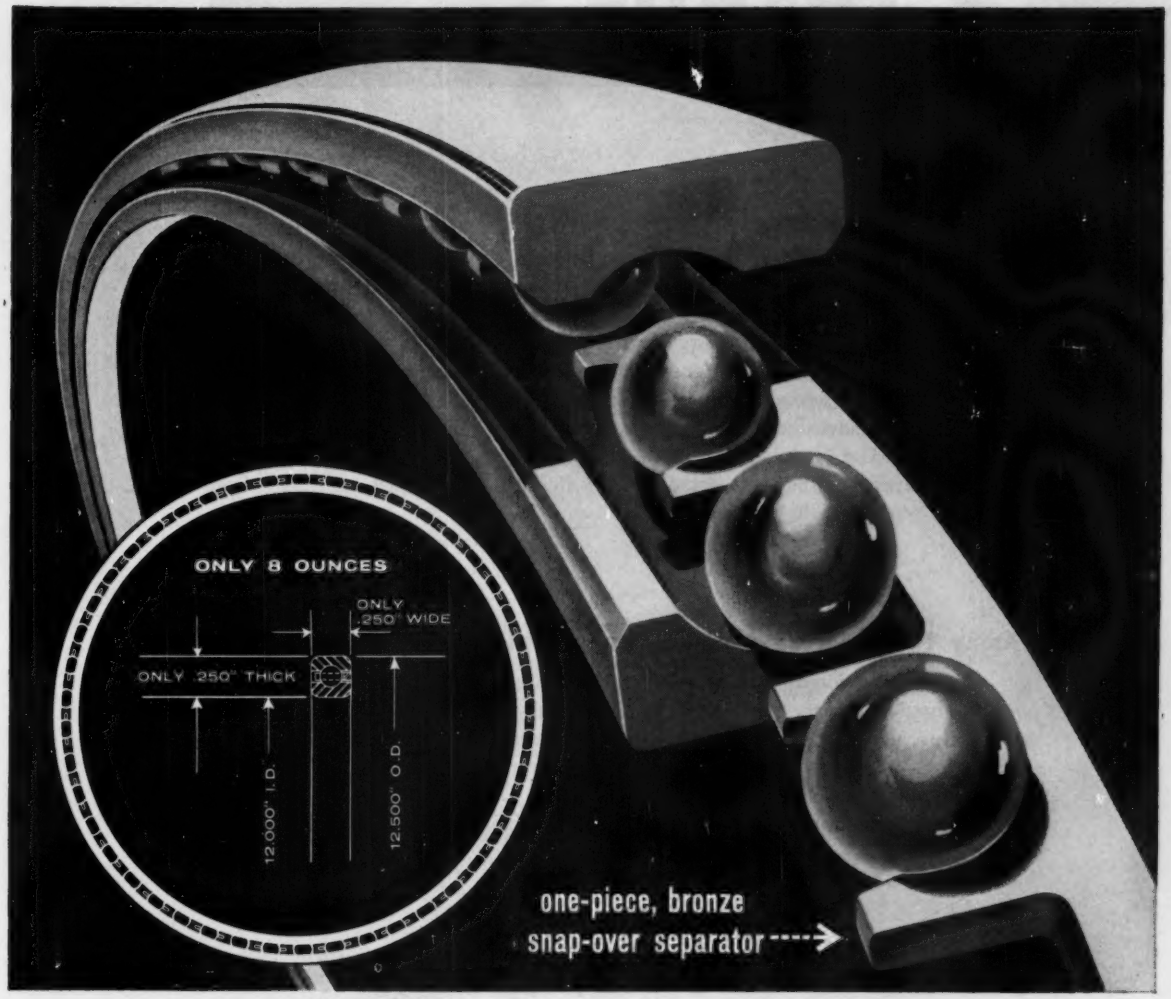

News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

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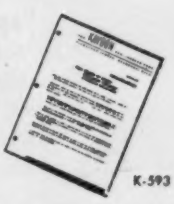
Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical thin-section bearing applications.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.



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NEWS TRENDS

survey redefines qualities for success

"Getting ahead" depends a lot more on what you do than "who you know," a University of Michigan survey reveals. Important qualities turned up in the survey fall into three groups. The first group—most needed qualities—includes: Willingness to work hard, personal integrity, communication skills, powers of logic, self-confidence, adaptability, and understanding of human relations. The second group is less important, but still necessary: Intelligence, technical knowledge, social grace, aggressiveness, optimism, and previous experience. The "helpful but not necessary" group consists of knowledge of the humanities and business contacts. The findings were based on replies from top executives in 46 U. S. companies.

Army technical center will answer plastics questions

Newest addition to the Army's Picatinny Arsenal, Dover, N. J., is a plastics evaluation center. Established by the Defense Dept., the center will provide technical information in four areas—structural, electric and electronic, packaging, and mechanical. Universities and libraries will be kept up to date on findings, and help will be offered to Defense Dept. agencies, contractors, and suppliers. Information will also be made available to the public, through the Office of Technical Services.

cold neutrons—newest particle projectiles

Neutrons chilled to −400 F, so cold that they are hardly moving, are the latest bullets for the physicist's particle gun. They're used in experiments with water and other liquids to determine the exact nature of motions of atoms that make up the liquid. The cold neutron is "fired" at slow speed and low energy into the test liquid. It is able to penetrate atoms of even solid material, entirely unaffected by the atom's electric field. Moving more slowly than the targets, the neutrons are hit by the atoms and bounced out of the liquid at a high speed. Measured speeds of the bounced neutrons reveal the manner in which the atoms were moving. Indications are that atomic motions in water are more like those in a solid than those in a gas.

"specialist" computers are on the way

Industry's acceptance of automatic process and production control by computers underscores three trends, says Charles E. Jones, general manager of Daystrom's Control Systems Div., La Jolla, Calif. He predicts that in the next five years, there will be: 1. An upswing in smaller, less expensive single purpose computer control systems. 2. Closer attention given to improving analytical instruments and transducers. 3. Design of factory processing equipment based almost entirely on computer control. Over-all result: Industry will begin turning out many products that have been passed over because of speed required in processing operations.

design uses predicted for irradiated materials

Several industry research teams are predicting that radiated materials will soon get wide acceptance in design. They base their opinions on the fact that radiation often endows inexpensive materials with the superior properties of higher-cost materials. Polyethylene, for example, becomes an excellent heat insulator after exposure to a high-energy particle beam. It could thus replace Teflon in certain applications because it costs less, is lighter, and is more able to resist corona damage. Isotopes such as cobalt 60, strontium, and cesium are generally used in the irradiation process, but a growing number of firms are now building experimental electronic devices to do the job.

inflation shortens space trip

First American in space won't be staying there as long as originally planned. Instead of the intended 18 trips around the earth before coming home, he will make only three. Reason for the orbital cutback: Rising costs—the program was supposed to involve just $200 million, but costs have now spiraled to about $350 million. By cutting down the number of orbits, the planners feel they can safely reduce the number of tracking stations needed to watch over the vehicle. Plans still call for the first shot to take place in 1961.

new pumps needed to handle liquid metals

Nuclear engineers are taking a new look at pumps. Molten-metals, used as heat-transfer and working fluids in nuclear reactors, are still causing severe erosion and cavitation problems. Reactions are violent enough to break down the best available materials. Mechanics of the process are not entirely understood, but NASA-sponsored research at the University of Michigan may supply the answers. According to UM's Prof. F. G. Hammitt, liquid-metal pumps are limited by the point where cavitation occurs. This limit is a function of rotating speed, flow rate, and other factors. Once the limit is defined, he says, "we will design smaller and less expensive pumps."

ASME will research machine parts failure

When failure of a single part can cause the flop of a multimillion dollar missile, the time has come for industry to support a basic study on why machine parts fail, according to an ASME spokesman. Paul Lewis, an ASME committee chairman, points out that all past improvements in machine elements, particularly those that are subjected to contact stresses, have been made on the basis of new materials, better quality control, and new design techniques. "But because of the lack of understanding of the basic failure mechanism, designers are still unable to predict accurately the operating life of a given component." First items of study in the new ASME project will include bearings, gears, and cams. Industrial organizations will be contacted for help on the project, according to Mr. Lewis.

Button-size amplifier, held in tweezers, does the same job as a conventional chassis full of hardware. And size reduction isn't all that molecular electronics offers: The maze of wiring, connections, and components that are eliminated means a tremendous gain in over-all reliability.

Already successful in the lab,

Molecular Electronics

is set to trigger a revolution in electronic-component design

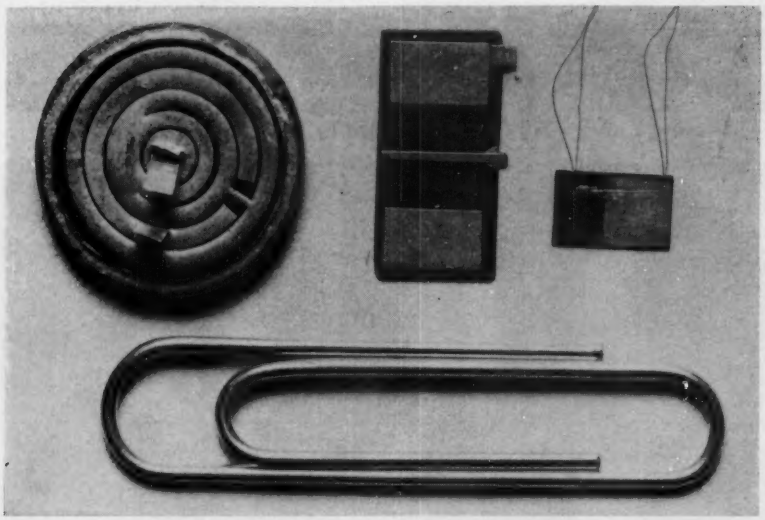
WASHINGTON — Practical limits in electronic miniaturization have probably been reached by conventional methods. The sophisticated black boxes crammed into today's missiles and aircraft represent size and weight reductions that would have been unbelievable a few years ago. Unfortunately, these boxes also contain a maze of midget circuitry that requires surgical precision at every stage of fabrication if failure rate is to be held within tolerable limits.

To solve the approaching size-weight stalemate, scientists at Westinghouse Electric Corp. have been working with a startling new concept called molecular electronics. The concept is based on solid-state phenomena, as are transistors and diodes. However, in molecular electronics, entire subsystems—amplifiers, oscillators, etc.—consist of a single crystal.

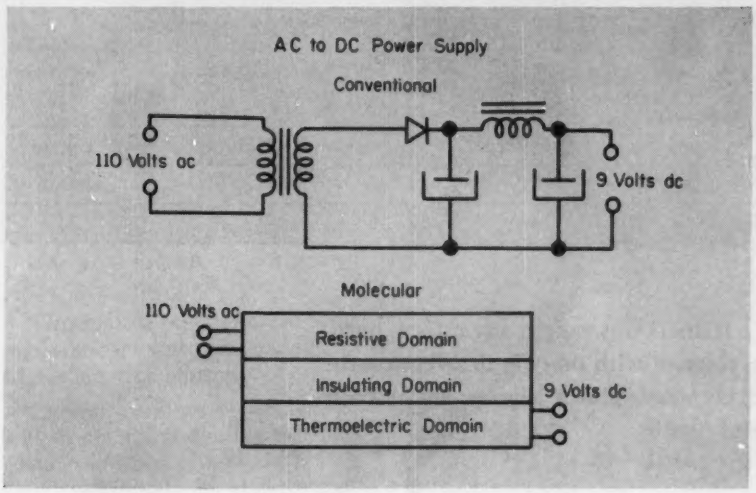
These tiny molecular subsystems, or "function blocks," have no internal connections or components; they require only external connections for coupling inputs and outputs to the overall system. Probability of failure is thus drastically reduced, and because internal functions involve distances of the order of a few atomic spacings, the blocks are microscopically small and virtually weightless.

Westinghouse is now producing eight classes of function blocks to demonstrate the feasibility of molecular electronics at frequencies ranging from infrared to direct current: 1. Directly cascaded 5-watt audio amplifier. 2. Two-stage video amplifier. 3. Frequency-selective amplifier. 4. Variety of multivibrators —bistable, monostable, and astable. 5. Variable potentiometer based on logarithmic addition of two inputs. 6. Variety of multiposition switches, including an "OR" switch. 7. Analog-to-digital converter. 8. Two-stage cooler employing the Peltier effect, covering frequencies from 1 cps to 3 mc, for cooling infrared detectors.

Design of a molecular subsystem, or function block, begins with an analysis of the job it is supposed to perform. After logic processes



One piece subsystems based on molecular electronics illustrate the size of circuits to come. Complete audio amplifier (left), multivibrator (center), and two-stage video amplifier (right), are smaller than many of the single components that would normally make up their circuitry.



Thermoelectric rectifier does the same job that ordinarily requires five separate components. Working on the Seebeck effect, the molecular device converts 110 volt ac to perfectly smooth 9 volt dc. Input current is applied to the resistive domain; heat is generated which passes through the center domain (an electrical insulator) into the thermal domain where it is converted into electrical energy.

are determined and suitable physical effects are settled on, a topologist (mathematician who works with shapes) determines the structure of the block by designing, on paper, the arrangement of "domains" and interfaces that will control the flow of energy in the block. Germanium and silicon are the basic materials used. Domains and interfaces are produced by techniques used in the production of conventional semiconductor devices, i.e., diffusion, plating, electron-beam machining, etching, cutting, radiation, alloying, and photographic processes. Final step in production is encapsulation of the function block to protect it against shock, vibration, and other adverse environmental conditions.

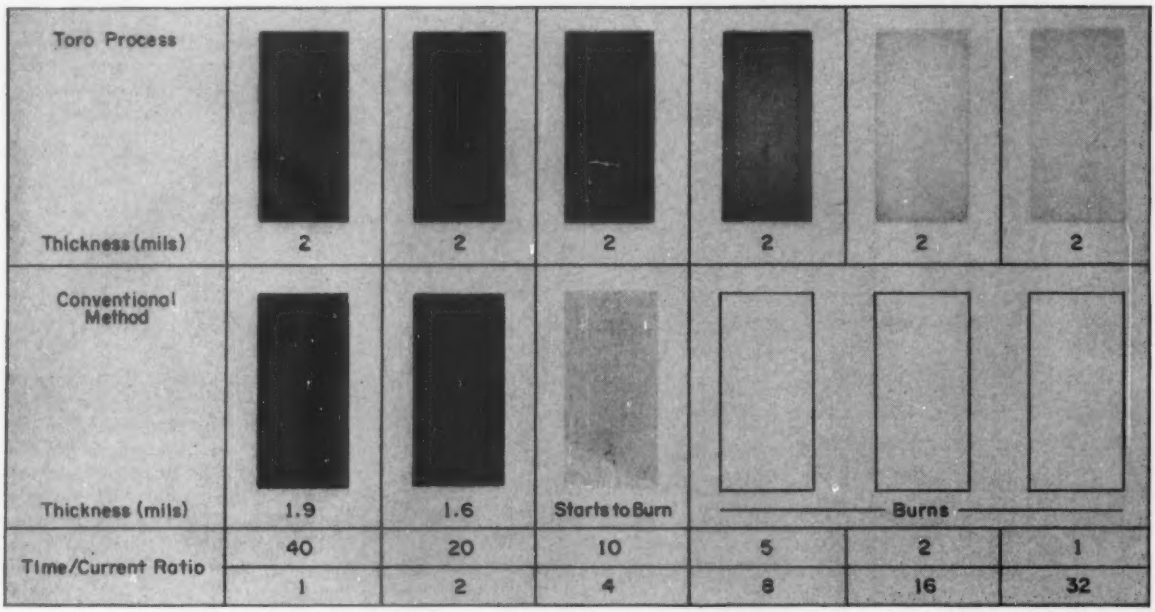
A number of solid-state phenomena are available to function-block designers. Seebeck generation (heat to electricity), Peltier cooling and Hall-effect multiplication are effects that have been built into the blocks so far. Although these phenomena will be used primarily for the control of electrical signals, they will also be suitable for control of electromagnetic radiation, heat, and mechanical-displacement.

The foundation of molecular electronics rests, ultimately, on materials and this is the area that Westinghouse is concentrating on now. While much success has obviously been obtained in creating, modifying, and processing semiconductor materials,"Entire pieces of electronic equipment will eventually be grown from pools of molten semiconductor materials," according to Dr. S. W. Herwald, Westinghouse vice president, research.

When will molecular electronics be ready for service? Dr. Herwald predicts that: "In three to five years the concept will be widely used in air/space electronic equipment, including telemetering, fire control, guidance, communications, and flight-control systems." After that, cost reduction and improved techniques should set the stage for commercial exploitation of molecular electronics. There was an 8-year interval between development of the transistor and its first uses.

News Report:

Color, coating thickness, and time are the key factors in anodizing. The Toro process produces light-colored coatings which are easily dyed; coating thickness exceeds all standards, and processing time is minimized by use of high currents. Secret of the process (why no burning occurs) has not been released by Toro.



Tougher than steel, and with a tremendous weight advantage, hard-anodized aluminum has been plagued with one big drawback—the anodizing process is prohibitively slow. But a leading lawnmower manufacturer couldn't wait, and now a

One-Minute Process Hard Coats Aluminum

MINNEAPOLIS — A new anodizing process ten to fifty times faster than conventional methods promises to pyramid the use of hard-anodized aluminum parts. Toro Manufacturing Co., Minneapolis, Minn., developed the new process to put a tough protective finish on aluminum reels in power lawnmowers. Conventional methods, the company learned, required that each reel be immersed in an electrolyte bath for 10 to 50 minutes to give the thickness needed. Translated into cost, this would have been prohibitively slow.

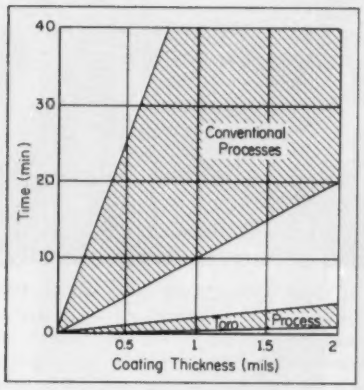
Toro assigned staff engineers at its Research and Development Center the job of finding a faster method. They did—after four years of developmental work.

Like other hard-aluminum anodizing processes, the Toro method electrochemically converts the surface of an aluminum part to a layer of aluminum oxide. Al_2O_3 is a hard, brittle material with a particle hardness of 9 on the Mohs' scale. (Diamond has a Mohs' value of 10.) Ability of the coating to withstand abrasion naturally exceeds that of hardened steel. (Hard anodizing differs from ordinary aluminum anodizing that is used largely for decorative and corrosion-resistance purposes. The decorative process uses low current and produces a very thin coating.)

Physically and chemically, the characteristics of Toro coatings are similar to those produced by four major (and slower) methods. A three-month evaluation conducted by the Armour Research Foundation, Illinois Institute of Technology, reached the conclusion that: "The comparative tests between conventional anodic hard coatings and Toro coatings leave little doubt that they are essentially the same in hardness, abrasion resistance, frictional properties, corrosion resistance, and density."

This is the only manner in which the Toro process resembles other anodizing processes. Toro coatings are light, silvery gray, compared with the dark gray and black coatings produced by other methods. The lighter color is more readily adaptable to dyes.

In conventional processes, electrolyte temperatures range from 25 to 52 F; current densities range from



One mil per minute is the average coating speed for the Toro process. This means that hard-anodizing is now suited to mass-production techniques.

20 to 100 amp per sq ft, and coating rates range from 10 to 50 minutes for a thickness of 0.001 in.

The Toro Process, by comparison offers these important gains:

- Temperature approximates room temperature, thus eliminating refrigeration requirements.
- Current density is between 20 and 40 times that of other methods; coating thickness of 0.001 in. is produced in one minute. However, allowable current densities (and, therefore, coating rates) depend generally on the surface-to-volume characteristics of the part. Thin extruded sections, for example, with low heat-sink capacities, could not be coated at the maximum rate.

Toro engineers readily admit surprise at the amazing improvements chalked up by their anodizing process. Don O. Benson, director of research and development for the company, sums it up this way: "If we had studied all of the literature on the subject before we began the project we would doubtless have become discouraged and dropped the whole thing. All available material indicated that there was no use in attempting to hard-coat aluminum quickly. But we are doing it."

Toro has made no definite plans to make the process commercially available. The company may build a plant of its own to get the process into commercial production.

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Circle 414 on Page 19

Atoms Get Sorted Twice, Come Into Better Focus

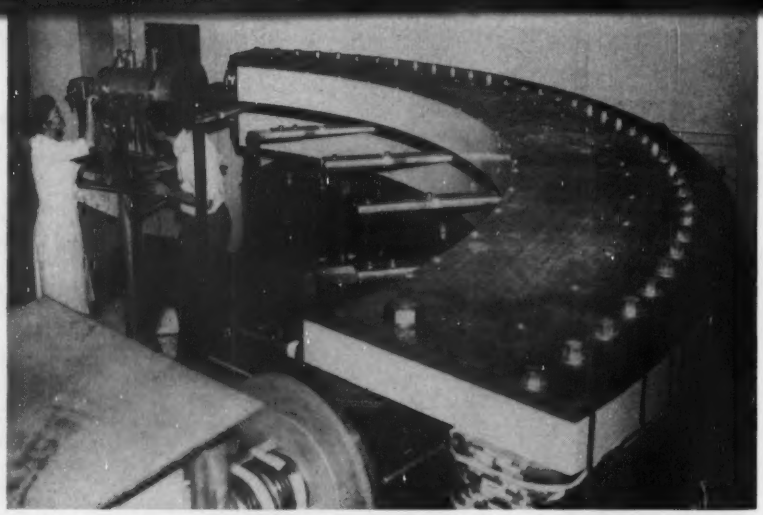
NEW TWISTS in mass-spectrometer design are making possible new precision in atom-weight measurements. A double-focusing instrument that is also one of the world's largest mass spectrometers boasts one hundred times the sensitivity and ten times the resolving power of its more conventional cousins. Shaped like a reversed letter S, the complex device is now operating at Argonne National Laboratory, Lemont, Ill.

By setting up a magnetic field around fast-moving charged particles, mass spectrometers bend the particles' paths, sorting them out by mass or mass-to-charge ratio. When the particles are positively charged atoms, the instruments determine relative numbers of different kinds of atoms in the particle stream, relative weight of atoms, and (via mass-to-energy calculations) amount of energy.

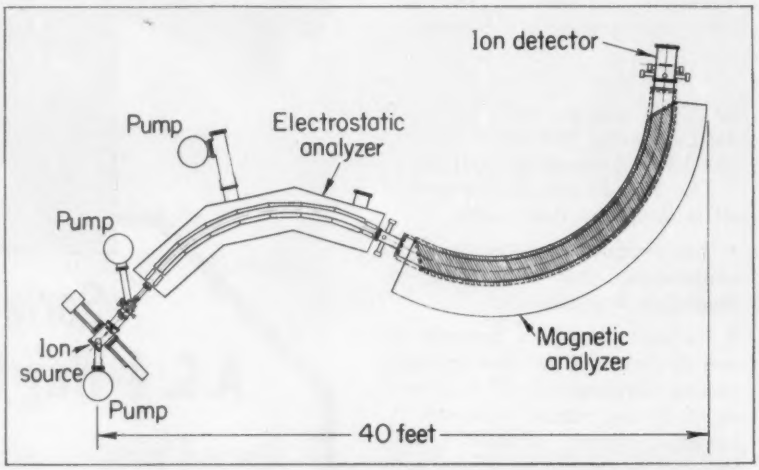
Argonne's new sorter does these jobs with greater accuracy than previously possible. It takes the particle stream through two sorting stages rather than the one stage normally used. First, in a curved electric field, it separates atoms by velocity—slower-moving atoms are more influenced by the field than fast-moving ones. After leaving the electric field, the particles (lined up according to velocity) go into a magnetic field with a reversed bend. Here, heavier particles are more influenced by the field than lighter ones. The net effect is that fast and slow particles of the same mass leave the field closely grouped.

Weighing 25 tons and measuring 40 ft in length, the instrument required six months for calibration. A typical list of its assignments reads like this:

- Analyze uranium isotopes in meteorite samples to determine whether unknown isotopes might be available in space.
- Search for natural isotopes that are believed to occur only in the debris of a nuclear explosion.
- Determine what kinds of atomic nuclei are created when target atoms are bombarded by particles from a high energy-accelerator.

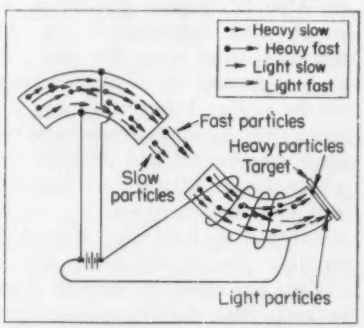


Magnetic analyzer of Argonne's new mass spectrometer is designed with a 100-in. radius of curvature. It's the second stage of a two-stage focusing system that sorts atoms by velocity, then by mass. The first stage, the electrostatic analyzer, is also designed with a 100-in. radius of curvature, but in the opposite direction. The two form a backward letter S. This unique sorting system gives the instrument unexcelled sensitivity and resolution.



Four main parts of Argonne's new mass spectrometer are the source unit, electrostatic and magnetic analyzers, and the collector unit. The vacuum pumps insure unrestricted motion of ions in the working units. Atoms are ionized and accelerated into the machine from the source unit, sorted according to velocity and mass in the electrostatic and magnetic analyzers respectively, and sensed and "observed" in the collector unit. The two analyzer stages are each curved segments of 100-in. radius circles. They make up a special focusing arrangement that is designed to give better sensitivity and resolution of data.

Charged atoms enter the first focusing stage (the electrostatic analyzer) in random orientation, leave lined up according to their velocities. In it, the slower moving atoms are more attracted to the negative (convex) wall than are the faster ones. In the magnectic analyzer, deflection caused by the magnetic field depends on both velocity of the atom and its mass. To focus the atom beams, Argonne engineers designed the second stage with a reversed curvature. Atoms of the same mass end up at the same location because, while slower atoms curve up more than faster atoms, they start below the faster ones. The machine was calibrated so that the velocity gradient was exactly compensated by the magnetic-field gradient.



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PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA

The "custom" approach to oil seal manufacture, pioneered by IPC, has resulted in some real off beat products.

None-the-less . . . they *work!* They suit the application *and,* in more cases than not, they have contributed substantially to cost savings.

When you're faced with a rugged problem involving oil seals, what synthetic compound comes to mind? How about case design? . . . friction? . . . torque? . . . shaft speeds?

Oil seals are an engineered product in themselves . . . just as good as their individual design. That's why we think each oil seal application deserves special "custom" thinking. That's why IPC oil seals are noted for performance. Let us show you what IPC can do to relieve your particular problem.

OIL SEALS / PACKINGS / PRECISION MOLDING *Custom designed for your application.*

IPC **INTERNATIONAL PACKINGS** CORPORATION

Bristol, New Hampshire

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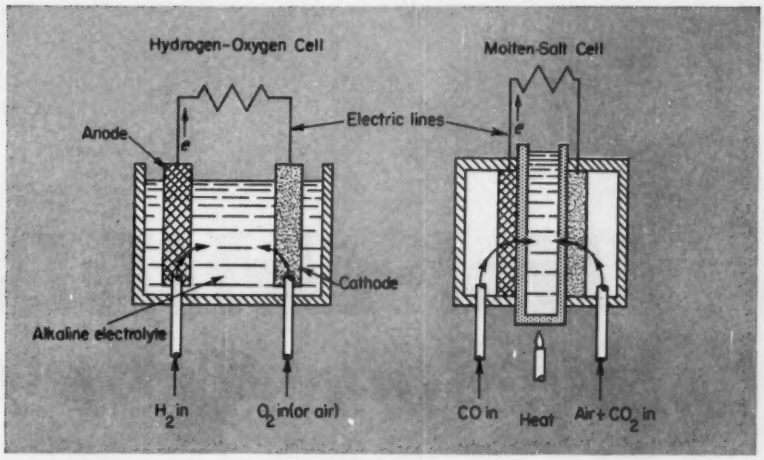
P-1



Electrons, liberated at the H-O cell's anode when hydrogen and hydroxyl ions combine to form water, travel via the electric circuit to the cathode. Here they're absorbed in a water-oxygen reaction that forms more hydroxyl ions. Excess water must be removed from the electrolyte.

Molten-salt cell's electrolyte operates between 500-1000 C. In the carbon monoxide cell, electrons are released when the fuel reacts with carbon trioxide ions. At the cathode, electrons, oxygen, and carbon dioxide combine to form more trioxide ions. Carbon dioxide produced at the anode comes off as a gas.

Status Report:

Army Rounds Up Fuel-Cell Progress

RESEARCHERS all over the world are taking a long look at the fuel cell. It' one source of electrical power that seems sure to find plenty of work in the coming years. But so many different designs for working models are turning up that the Army decided a review was in order. Here are the highlights of what was turned up.

The broad definition of a fuel cell —an electrochemical device in which part of the energy derived from a chemical reaction, maintained by a continuous supply of chemicals, is converted into electricity—covers lots of different systems. The Army classifies the cells into five main types: 1. Hydrogen-oxygen. 2. Molten-salt electrolyte. 3. Redox. 4. Regenerative. 5. Consumable electrode.

Lab Models and Pilot Plants

The hydrogen-oxygen cell has now reached an advanced stage of development. Two systems — one based on low temperatures and pressures, the other on high temperatures and pressures—are well into pilot plant operation. The high-temperature system is being used in 1.5 and 10-kw generators scheduled for delivery to the military soon. Development of sources for both hydrogen and oxygen is progressing. Possibly solar or nuclear energy could supply the gases through the electrolysis of water.

The molten-salt cell operates at high temperatures on such plentiful and cheap fuels as carbon monoxide, methane, or any combination of gaseous hydrocarbons. Although studied for a number of years, it's still in the laboratory stage. Power outputs are low and high temperatures limit its potential, but central power station generation is likely because of low fuel cost.

The redox cell, also in early stages of development, uses its fuel indirectly—the fuel regenerates the electrolyte and the electrolyte takes part in the chemical reaction. Electrochemical and regenerative processes can be separated and fuel quality can be low. Work has not yet progressed to the point where the

(*Please turn to Page* 34)

Performance of Typical Cells

Type of Cell	Operating Conditions: Temperature (C)	Pressure (atm)	Voltage (v)	Current Density (amp/sq ft)	Power Output: Per Unit Weight (watt/lb)	Per Unit Volume (watt/cu ft)	Life	Efficiency (per cent)
Hydrogen-oxygen	50-60	1-5	0.95-0.6	90-450	2-3	200-300	>1000 hr	65-70
Hydrogen-oxygen	200-240	40-53	1.0-0.6	30-1000	15-20	2000	1500 hr	80 max
Molten salt	700-800	1	0.96-0.54	30-1000	...	100-1000	several hr	65 max
Molten salt	500-730	1	0.84-0.5	10-70	...	800	6 months	70 max
Redox	80-85	1	0.8	40	8	300-460	1 week	80 max
Redox	20-90	1	0.62-0.29	9-46	...	...	...	60 max
Heat regenerative	450*	near 1	0.4-0.36	150 max	2	90	...	10-12
Consumable electrode	45	1	1.76-1.21	25-150	...	2.8	1 year	...
Consumable electrode	Room	1	1.95	15	...	...	12 hr	...

*Regeneration temperature—850 C.

Twin Disc Builds
of Single-Stage Torque

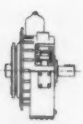
...including one that's RIGHT for your drive line design

The Twin Disc nameplate was on the first industrial torque converter built in America. That was in 1937 and Twin Disc has set the pace in converter design ever since. Today Twin Disc is the world's largest producer of industrial torque converters and the only manufacturer of both three-stage and single-stage models.

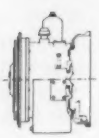
Every year brings wider recognition of torque converter advantages—the advantages of automatic torque multiplication to match load demands ... elimination of engine lugging and stalling ... smooth, accurate control under all load conditions ... absorption of shocks and vibrations to safeguard driving and driven equipment.

When you want to incorporate these advantages into your drive line design, a consultation with Twin Disc application engineers may prove worthwhile. In single-stage units alone, Twin Disc offers six basic types and 25 individual models with a wide range of capacity and torque transmission characteristics. One of these Twin Disc converters is almost certain to meet your requirements. Request Bulletin No. 510.

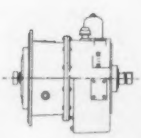
"Stripped" units for OEM in-line design
Nine models—11", 13" and 15" sizes.
Torque ratings from 235 to 650 lb.-ft.
Three types: Converter only; converter with oil-actuated disconnect clutch; and converter with disconnect clutch and lock-up direct drive clutch.



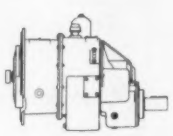
Basic power take-off units
Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.



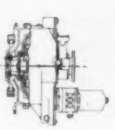
Spacer units for connection to transmissions
Three models—13" and 15" sizes.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Available with dummy flywheel for automotive type clutches.



Units equipped with front-end disconnect clutch
Four models—13" and 15" sizes.
Single or double plate clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel for shovels and cranes.



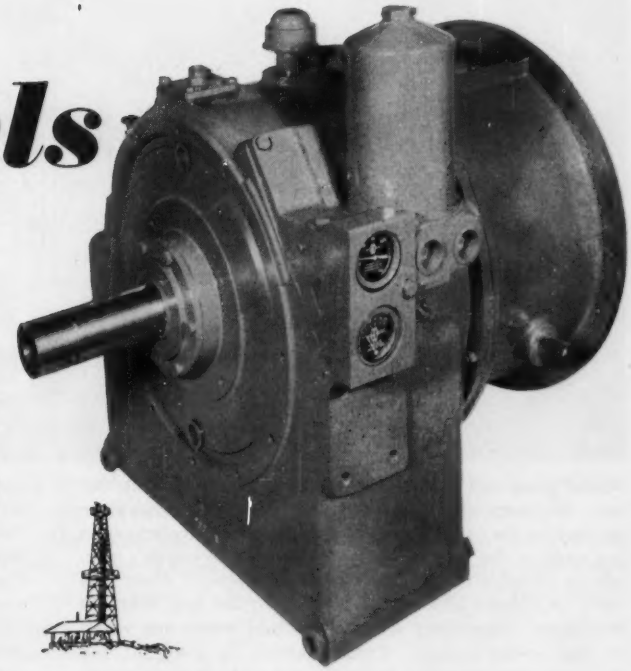
Units equipped with disconnect clutch plus 2:1 ratio reduction gear
Three models—13" and 15" sizes.
Single or double plate 11" clutch.
Torque ratings from 350 to 650 lb.-ft.
Suitable for side loads.
Optional: Boom lowering freewheel.

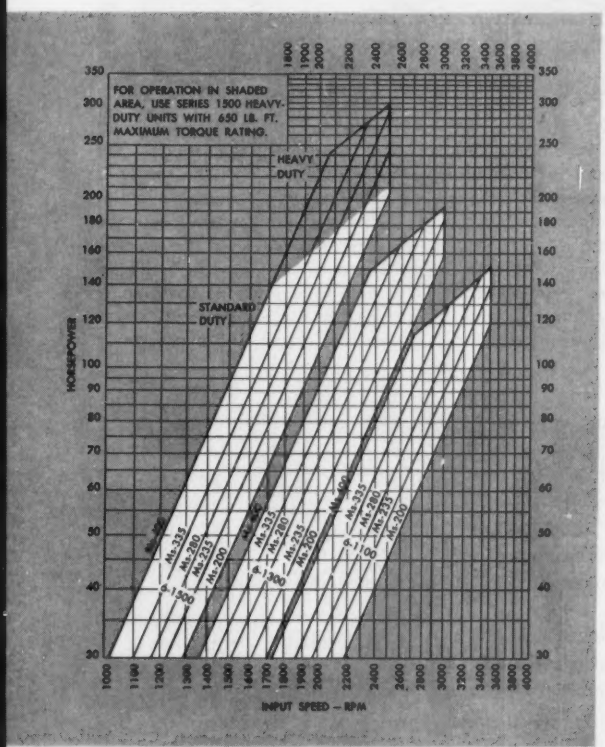


Sumpless PTO units for power-shift transmissions
Three models—13" and 15" sizes.
Live power take-off for auxiliary drives.
Torque ratings from 350 to 650 lb.-ft.
Flanged output shaft.
Optional: Rubber block input drive.

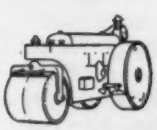
TWIN DISC CLUTCH COMPANY, RACINE, WISCONSIN

25 Models
Converters




FOR OPERATION IN SHADED AREA, USE SERIES 1500 HEAVY-DUTY UNITS WITH 650 LB. FT. MAXIMUM TORQUE RATING.
HEAVY DUTY
STANDARD DUTY
HORSEPOWER
INPUT SPEED — RPM

The above chart gives horsepower and speed ratings of 1100, 1300 and 1500 Series Single-Stage Torque Converters. Maximum capacities are 300 hp and 3500 input rpm.



TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC
Torque Converters

HYDRAULIC DIVISION: ROCKFORD, ILLINOIS

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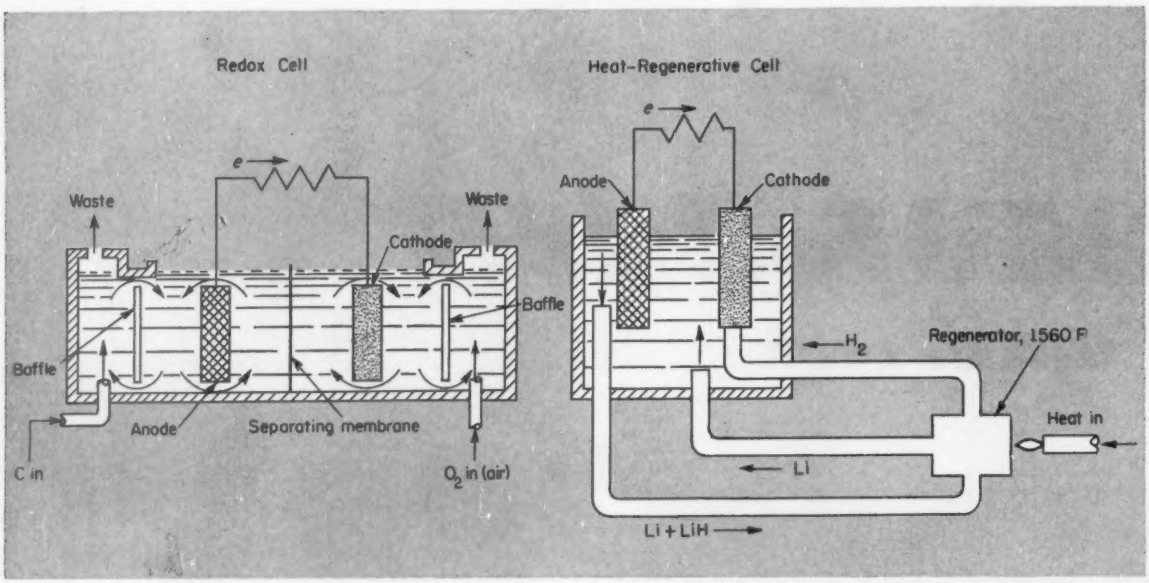
FUEL CELLS



Future plans call for many types of regenerative cells, but only the redox and heat regenerative systems have been studied so far. In the redox system, different electrolytes are used in the two halves of the cell. The anode's electrolyte contains tin ions that lose two electrons when they come in contact with the electrode. At the fuel inlet, the tin "super" ions react with carbon and water and revert to their initial charge. Carbon dioxide is given off and hydrogen ions are also formed. The cathode's electrolyte contains bromine atoms that pick up the electrons and become ions. As the electrolyte circulates, the ions react with hydrogen ions (brought over from the anode) and oxygen to form bromine atoms and water. The water is transported to the anode cell for further regeneration of the anode's electrolyte. In the heat regenerative cell, the electrolyte is a lithium halogen solution. At the anode, lithium atoms lose electrons and at the cathode hydrogen atoms gain electrons. The two types of ions combine in the solution to form lithium hydride. The hydride is heated to 1560 F, breaking it down into lithium and hydrogen.

(*Continued from Page* 31)

cell's potential can be evaluated, however.

Other regenerative fuel cells are also possible. Among those attracting attention are the photochemical, radiochemical, electrolytic, and thermal cells. So far only the thermal cell has received any fairly extensive experimental study. Efficiencies of thermal energy sources are limited by the Carnot cycle, and this cell won't be as efficient as some of the others. Applications seem limited to situations where large quantities of cheap heat are available—possibly nuclear or solar sources.

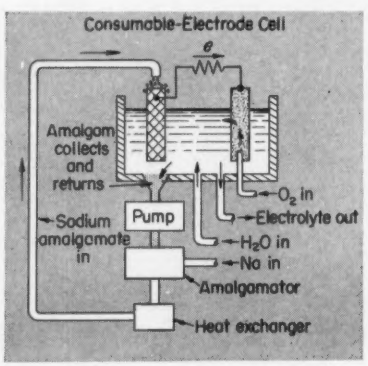
Consumable electrode systems operate at low temperatures with high power-to-weight ratios. The systems have proved practical and several pilot plants using this type cell are in operation.

Pros and Cons

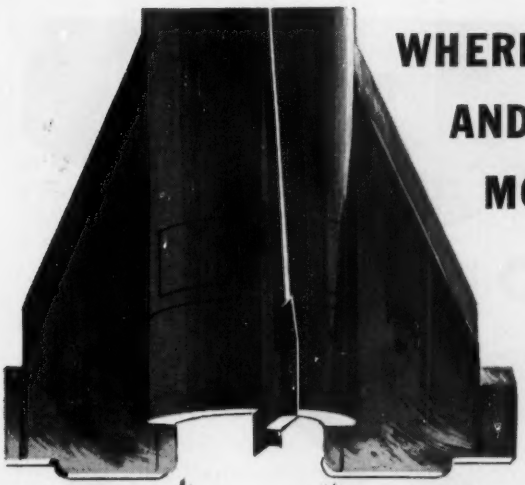
Each cell of a fuel-cell system produces about 1 v, but series hookups can bring voltages up to needed levels. The fuel cell has advantages that require careful evaluation:

- It's more efficient than conventional electrical power generators. Experimental systems operate up to 80 per cent efficiency—about double that of conventional equipment.
- Waste products from the chemical reactions cannot be detected—there's no noise, heat, smoke, or other objectionable products.
- It contains no moving parts and therefore requires negligible maintenance.
- Vibration, shock, and climatic extremes have no effect on operation.
- It boasts extremely high power-to-weight and power-to-volume ratios.
- It operates on a variety of fuels and, in some cases, a number of readily obtained low-grade fuels interchangeably.
- Fuels produced for the chemical reaction can either be used immediately or conveniently stored until needed.

Not all fuel cells feature all these advantages. But, depending on the application, not all the advantages are equally important. In a large



Electrode acts as a fuel in the sodium amalgamate cell. Sodium amalgamate flows down a steel anode and the sodium goes into solution, giving up electrons. The amalgam collects at the bottom and is recycled. More sodium is added and after the fresh batch is cooled (in the heat exchanger), it's returned to the cell. At the cathode, the electrons combine with oxygen and water to form hydroxyl ions. These ions travel to the anode where sodium hydroxide is produced. The electrolyte (sea water) must be continuously changed to prevent the sodium hydroxide from contaminating the cell.



WHERE INCREASED TENSILE, IMPACT AND TEMPERATURES COUNT... MORE ENGINEERS COUNT ON

MIDVAC STEELS

Where maximum reliability and minimum rejects, due to failure to meet mechanical properties, must be attained... more and more engineers are specifying Midvac super alloy steels.

The Midvac process of consumable electrode melting eliminates atmospheric contamination, ingot soundness is improved, segregation is reduced and workability is increased. Ingots and billets produced for missile components, jet engine and aircraft parts and super bearings show increased tensile strength and impact, improved stress rupture at elevated temperatures and longer fatigue life.

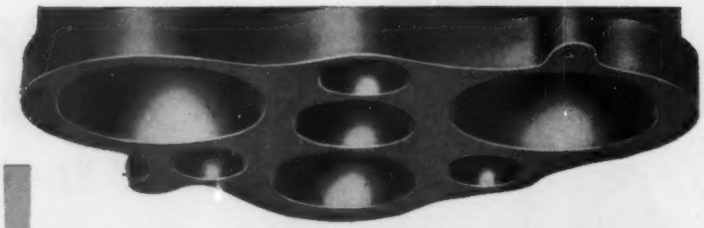
The table below shows just a few of the many super alloys being processed by Midvac. Our metallurgical engineers are ready to help you select or specify the Midvac Steel to meet your requirements. Write for complete technical data.

MIDVALE-HEPPENSTALL COMPANY
NICETOWN, PHILADELPHIA, PA.
SUBSIDIARY OF HEPPENSTALL COMPANY — PITTSBURGH, PA.
Plants: Pittsburgh, Pa. • Bridgeport, Conn. • New Brighton, Pa.

Alloy	Melting Process	Yield Strength .2	Ultimate Tensile Strength	Percent Elongation	Percent Reduction of Area
A-286	Air Melt	99,000 psi.	132,300 psi.	9.0%	14.7%
	Midvac	117,000 psi.	150,500 psi.	21.3%	33.8%
Gannalloy	Air Melt	112,000	159,900	13.0%	21.0%
	Midvac	142,600	177,250	18.0%	31.6%
D6A-C	Air Melt	234,800	281,000	4.9%	20.6%
	Midvac	256,700	294,250	9.6%	28.4%
Tricent	Air Melt	238,600	284,500	6.1%	19.7%
	Midvac	254,300	291,600	10.3%	25.6%

Properties shown are averages of 25 heats

MH *Midvac Steels*



NEW! FROM UNITED

Metallic O-Ring retainer plates cut machining and assembly costs!

Now mating flanges can be sealed without machining grooves to hold metallic O-rings! To complement its own famous line of metallic O-rings, United introduces machined metal retainer plates, which are available to match most two-dimensional junctures, regardless of the number of ports. Plates hold one or more O-rings securely, minimizing the possibility of O-ring dropout and possible contamination or loss. Using United retainer plates, flange assembly time can be cut because plate and O-rings are handled as a unit.

Openings in United's retainer plates function the same as conventional groove walls. They furnish an automatic O-ring compression limit . . . control O-ring hoop tension . . . position O-rings for accurate matching of multiple hole patterns in mating flanges . . . simplify surface finish operations . . . and permit interchangeability of flanges. For immediate price quotations, send drawings of flange configuration, together with specifications regarding fluids, pressures and temperatures to:

Contractual Engineering Offices:
CALIFORNIA.....1101 Chestnut St., Burbank, VI 9-5856
NEW YORK.....50 E. 42nd St., New York 17, MU 7-1283
OHIO.....1116 Bolander Ave., Dayton, BA 4-3841
CANADA.....United Aircraft Products, Ltd., 147 Hymus Blvd. Pointe Claire, P.Q., Phone Montreal: OX 7-0810

UNITED METALLIC "O" RINGS
manufactured by
United Aircraft Products, Inc.

Circle 419 on Page 19

power station, for example, efficiency and ability to use cheap fuels are the prime requisites, ability to operate quietly is less important.

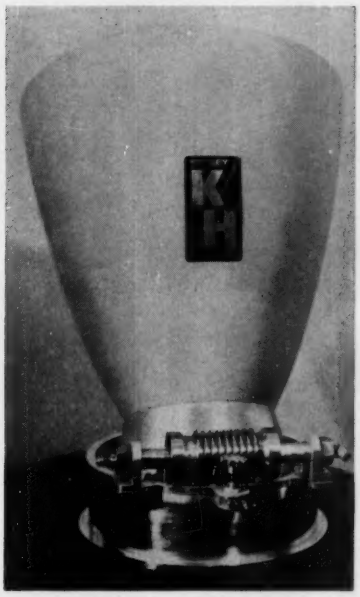
Three disadvantages tend to offset advantages in some applications:

- Electrical power is limited to dc output.
- With some systems, a large amount of auxiliary equipment is necessary.
- Large quantities of power per unit weight cannot be generated in a short time—the silver-zinc batteries are much superior in this respect.

Although research and development are continuing, breakthroughs seem improbable in the near future, says the Army. A complete review of research now going on is presented in the Army's report ("Status Report on Fuel Cells") available through the Department of Commerce.

Missiles Land on Air in Recovery Operation

Belly-whopping missiles, landing on inflatable cushions which they carry, are cutting costs of Air Force training flights. Neoprene-coated nylon "recovery bags," made by Goodyear's Aviation Products Div., fill with compressed air to absorb landing shock of the TM-76-Mace tactical missile. First step in recovering one of these vehicles is throttling the jet engine to 60 per cent power (done by radar control); then a drag parachute is ejected to brake the speed. At 2500 ft, three 100-ft cargo chutes open. Finally, as the missile nears the ground, two recovery bags pop into shape to cushion the landing. Besides its very practical purpose of saving missiles, the recovery operation offers opportunity for examination of guidance systems which have not functioned properly.



Solid-Rocket Nozzle Steers by Swiveling

New course corrector for small rockets —an integrated nozzle and nozzle-actuator package—is a thrust-vector control for solid-fuel engines. Developed by Kelsey-Hayes Co., Detroit, the nozzle is of the turret type. It is the latest addition to the KH thrust-vector controls which include turret types, pivot types, and others. All have been successfully test fired.

Tiny Pressure/Force Transducer Has No Moving Parts

Deformations in a Polymer Control Electric Output

SOMERVILLE, MASS. — A new wafer-like transducer responds instantaneously to pressure changes, can be calibrated for just about any range, and has no moving parts to cause failure. Many unusual applications are predicted because the unit operates accurately even when flexed or stretched and it can take overloads of several thousand per cent.

Developed by International Dynamics Corp., South Boston, Mass., the device uses a polymer as a sensing element. Electrodes are attached to upper and lower surfaces and a constant voltage is applied. Current flow through the polymer depends on its conductance and conductance varies with applied pressure. The wafer can be made almost any size or shape desired (even as small as 1-mm diam), and since applied pressures cause only a slight molecular deformation, the unit's dimensional changes during

(*Please turn to Page 40*)

One job for the new transducer is measuring acceleration. The accelerometer shown is a 500-2500 G unit weighing less than 3 oz. It's capable of responding to variations in applied force that occur as often as 1000 times per sec. It responds to forces in only one direction and gives no response to accelerations in other directions.

"In modern manufacturing, electrical control equipment is the very heart of mechanized and automatic operation. Because our plants have become so dependent on this equipment, the cost of 'down time' for any control failure is simply staggering. And, according to many manufacturing engineers, limit switches are the worst offenders, accounting for as much as 70% of all interruptions due to control failures."

Mr. J. S. Wilford, Editor
PRODUCTION Magazine

"At least 60% of the electrical failures causing downtime of the production machinery used in manufacturing home appliances at the Whirlpool Corporation can be traced to faulty limit switch operation. An analysis of the switch failures reveals the inability of limit switches to meet the requirements of high production equipment such as is widely used in our St. Joseph Division."

Mr. C. R. Burg, Maintenance Engineer,
Whirlpool Corporation

"75% of the electrical failures on our machines can be traced directly to limit switch malfunctions. This problem is particularly aggravating to us because we are responsible for the successful operation of our machines and their components on our customer's floor. We have spent a great deal of time engineering protective mounting schemes to compensate for the inability of today's limit switches to check the seepage of corrosive coolants and microscopic grit."

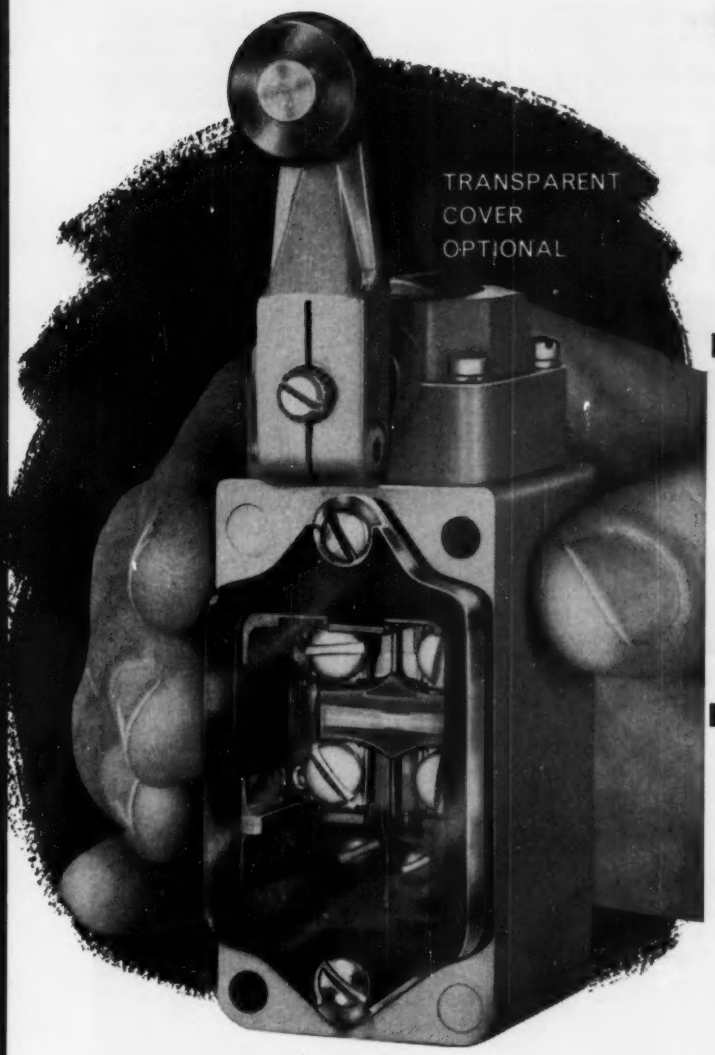
Mr. N. P. Bashor,
Director Electrical Division,
W. F. & John Barnes Company

Production's Enemy #1 MEETS ITS MASTER

Cutler-Hammer announces the *first*

- ***Tolerance Compensated***
- ***Contamination-proof***
- ***Visible Contact***

Extended Life Limit Switch



■ *Tolerance Compensation*

The new Cutler-Hammer Extended Life Limit Switch represents a startling break-through in high-precision manufacturing methods. Each sub-assembly is accurately calibrated so that in final assembly all plus and minus tolerances are precision balanced or compensated. Thus, tolerance compensation guarantees every C-H Extended Life Limit Switch will operate identically with precise repeat accuracy and ultra-long life. No binding . . . no sticking . . . no points of concentrated stress or wear.

■ *Contamination-proof*

New triple sealing positively checks seepage of all forms of oil, coolants, moisture, and abrasive grit. New cone-seal stops seepage through the operating shaft bearing. New vulcanized bellows-seal between the operating head and body eliminate the troublesome "O-ring" seal . . . won't wear . . . never needs attention. New cover seal seats on a raised lip . . . repeated opening and closing of the cover won't destroy the seal. Total-submersion life tests prove the new C-H Extended Life Limit Switch to be contamination-proof . . . suitable for even dry circuit applications.

■ *Visible Contacts*

Another Cutler-Hammer *first* . . . this new Cutler-Hammer Limit Switch provides completely enclosed but *visible* single pole double throw switch contacts. During installation, one glance shows which contacts are open and which are closed . . . no chance for wiring errors. During operations, one glance proves whether the switch is set and operating correctly. Positive visible inspection cuts maintenance costs too.

Compare these features, too!

- **One basic model is readily adapted to all desired forms of lever or plunger actuation . . . for either momentary or maintained contacts . . . for either surface or cavity mounting.**
- **Unsurpassed flexibility: 90° orientation of the operating head. 360° rotation of lever arm with a locking device that holds the adjustment. Lever operators provide clockwise, counter-clockwise, and clockwise-counter-clockwise actuation . . . easy to set on the job without disassembling the switch.**
- **Precise actuation . . . 10° pretravel—40° overtravel or 5° pretravel—45° overtravel.**
- **Visible, saddle-clamp terminals . . . no loose fibre flash-over barriers.**
- **Unitized switch mechanisms are interchangeable . . . speeds replacements when overload or short circuit damage occurs.**
- **Meets all JIC and NMTBA requirements. Easy, complete interchangeability with any widely used limit switch.**

The new Cutler-Hammer Extended Life Limit Switch installs easier, works better, and lasts longer than any of the "oil-tight" limit switches now in use. Exhaustive tests, including total-submersion life tests, confirm this fact! But don't take our word for it. Try it . . . Test it . . . Compare it. The new Cutler-Hammer Extended Life Limit Switch is completely interchangeable with any widely used limit switch. Replace your *most* troublesome limit switch installation with this new tolerance compensated, contamination-proof, visible contact Cutler-Hammer Limit Switch; and it will work better, last longer than any other you have ever used. This is the answer to your limit switch problems.

For descriptive data write for Publication ED143-D243. Cutler-Hammer, Inc., Milwaukee 1, Wisconsin.

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

Circle 420 on Page 19

SPECTROL PRECISION MECHANISMS

Kerosene, Jets & Fuel Flow

Spectrol developed its newest PRECISION MECHANISM—A Pulse Totalizer—for an airborne system which measures fuel flow with particular accuracy. But this carefully-designed electromechanical counter has many uses. You can apply it to any sort of pulse counting scheme, airborne or ground, where electrical output is required.

The Totalizer features 5 decade switches, each having a string of precision resistors to give electrical readout. It also has a built-in amplifier which makes the input interesting—20 volts into 10K impedance. Operating from dc power, the unit will count up to 15 counts per second. There's a manual reset and, as you can see, visual readout.

How It's Used. The Pulse Totalizer is part of a fuel measuring system aboard a jet airliner. A flowmeter acts as a transducer, and an amplifier delivers pulses proportional to the number of gallons to the Pulse Totalizer. The output from the Totalizer is delivered to multi-channel recorders as an indication of how much fuel was consumed per unit time. The visual readout feature of the Totalizer also permits its use on a photo panel aboard the aircraft for studies of fuel flow rate and total consumption.

This is another example of how Spectrol PRECISION MECHANISMS free the systems engineer from building functional subassemblies. If you need modules using components such as gear drives, clutches, precision potentiometers and servomotors —Spectrol can help.

For more details, call your Spectrol engineering sales representative, or address Dept. 57

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SPECTROL

ELECTRONICS CORPORATION
1704 South Del Mar Ave. • San Gabriel, Calif.

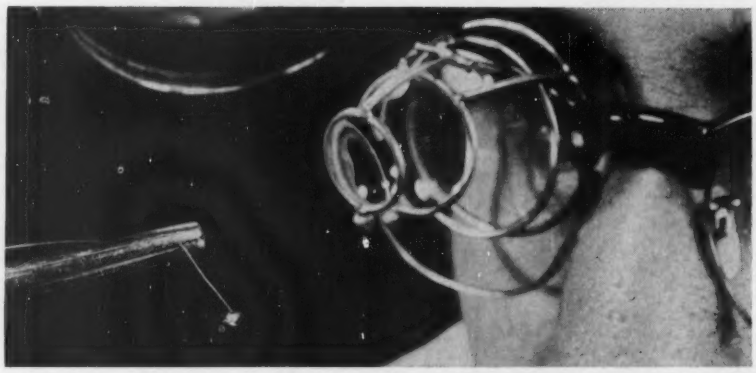
Circle 421 on Page 19

(Continued from Page 37)

operation are negligible.

Transducers are now being designed for individual applications by IDC; no mass-production devices are on the market. The polymers used are restricted to temperatures below 230 F, but the company expects to lick this limitation in the near future.

Radiation Detector Fits in Hypodermic-Needle Tip



Tiny radiation detector accurately measures number and energy of high-speed atomic particles. It's an inexpensive solid-state device claimed to be more sensitive than any earlier detector. Essentially a thin slice of "doped" silicon, the device emits a measurable pulse when struck by a charged nuclear particle. Developed by Hughes Aircraft Co., Culver City, Calif., it's already being used in a cigar-like storage tube that also contains a battery and amplifier (right).

Meetings and Shows

March 6-9—

American Society of Mechanical Engineers. Gas Turbine Power and Hydraulic Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

March 7—

Cleveland Engineering Society. Seventeenth Annual Machine Design Conference, sponsored by the Machine Design Div. of the society, to be held at the Cleveland Engineering and Scientific Center. Additional information can be obtained from Donald H. Cornish, Executive Director of CES, Cleveland Engineering and Scientific Center, 3100 Chester Ave., Cleveland 14, Ohio.

March 7-8—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 14-18—

National Association of Corrosion Engineers. Annual Meeting to be held in Memorial Auditorium, Dallas. Additional information is available from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 15-17—

Society of Automotive Engineers Inc. National Automobile Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additonal information can be obtained from SAE

JUST OUT!

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HERE are all the facts, all the features of Link-Belt's new spherical roller bearings. Book 2760 is packed with diagrams, photos, charts, formulas—explains the unmatched performance and economy advantages of these self-aligning bearings. And there's an illustrated section on the machines and procedures that enable Link-Belt to maintain the strictest tolerances ever achieved in standard bearings. For your copy, mail the coupon today!

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Dept. MD, Prudential Plaza, Chicago 1, Ill.
Please send a copy of the new Spherical Roller Bearing Book 2760.

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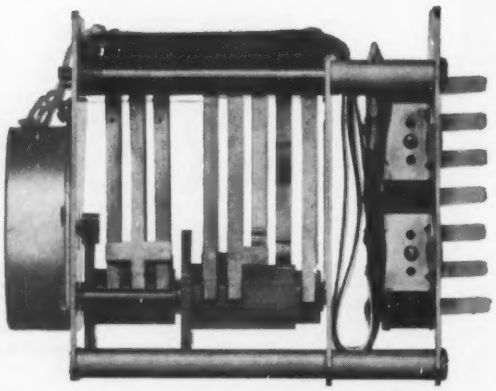
Circle 422 on Page 19

The A. W. Haydon Co. designed this series of repeat cycle timers for engineers with tricky timing problems and tight budgets. The low unit price on quantity runs will surprise you...and the savings we can offer on very large volume production sometimes surprises us! ■ Yet there has been no sacrifice in quality...it's all in the design. Special spring switches are supported in molded contact blocks; cams, cam followers and gears are molded nylon for long service life and extremely quiet operation. Two printed circuit cables supply internal wiring to 12 output circuits, and parallel cam shafts provide two cycling speeds. ■ The A. W. Haydon Co. guarantees this repeat cycle timer for at least one year, continuous operation, and it will actually run for much longer. ■ The unit shown operates at 115V, 60 CPS, 2.5 watts power input. Its switch has been tested for 2 years (125 million cycles at 2 amps resistive 10VAC, 60 CPS) and is rated for 2.5 amp or a 7.0 amp inrush lamp load. ■ To be sure, other variations are available. A. W. Haydon will be delighted to quote these long life, low cost repeat cycle timers in any one of 125 standard speeds, 5 voltage ratings and 3 power supplies. All have Jones type terminal plugs for fast installation, and a quick-change motor mounting for ease of motor replacement. A clear plastic dust cover helps reduce noise level to a whisper. Write for information on your particular requirement.

LONG LIFE LOW COST REPEAT CYCLE TIMERS



THE AWH HAYDON COMPANY
249 North Elm Street, Waterbury 20, Connecticut

headquarters, 485 Lexington Ave., New York 17, N. Y.

March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 22-24—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Statler Hilton Hotel, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 23-25—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Carter Hotel, Cleveland. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 27-31—

Scientific Apparatus Makers Association. Annual Meeting to be held at Boca Raton Hotel & Club, Boca Raton, Fla. Additional information is available from SAMA, 20 N. Wacker Dr., Chicago 6, Ill.

March 29—

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

March 29-31—

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sherman, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

April 3-6—

National Screw Machine Products Association. Annual Meeting

to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from association headquarters, 2860 E. 130th St., Cleveland 20, Ohio.

April 3-8—

Nuclear Congress to be held in the New York Coliseum, consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition. Congress is sponsored by 28 engineering, scientific, management, and technical organizations. Further information is available from 1960 Nuclear Congress, 33 W. 39th St., New York 18, N. Y.

April 4-7—

American Management Association. 29th National Packaging Exposition to be held at Convention Hall, Atlantic City, N. J. The National Packaging Conference also will be held at Convention Hall, April 4-6. Further information is available from AMA, 1515 Broadway, New York 36, N. Y.

April 5-8—

Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at the Hotel Commodore, New York. Further information can be obtained from the society, 485 Lexington Ave., New York 17, N. Y.

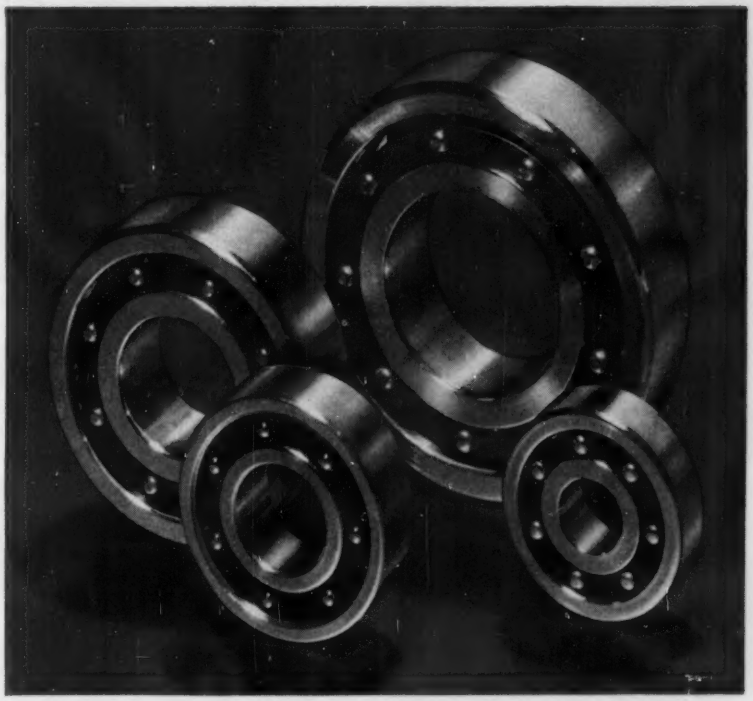
April 7-8—

American Society of Mechanical Engineers-Society for the Advance-

"For the last time—stay out of the wind tunnel!"

900° F. STOCK BEARINGS

PERMIT RAPID SOLUTIONS TO HIGH-TEMP PROBLEMS



TYPE: Deep groove radial.	RETAINERS: Machined, land riding.
SIZES: 200, 202, 204 and 206.	ACCURACY: ABEC-5.
BALLS AND RACES: High speed steel.	LUBRICATION: None.

THESE NEW ITI ball bearings are for use at elevated temperatures up to 900° F. At such temperatures, their load capacity is greater than any other bearings of like size, and they have unusual dimensional stability. They open new horizons in developmental work, because (1) they provide a first approximation to the solution of a wide range of high-temperature bearing problems; (2) they're *available from stock;* and (3) they *cost far less* than custom-made experimental bearings.

The suitability of a bearing to *any* high-temperature application depends on many factors.* Upon receipt of application data, we will tell you whether these "off-the-shelf" bearings will serve your purpose. Prices and other details are also available; and we invite your inquiry.

*FREE BULLETIN AFB-2 gives details; also describes our work in *custom-engineered* bearings. Write for it.

INDUSTRIAL TECTONICS, Inc.

ITI

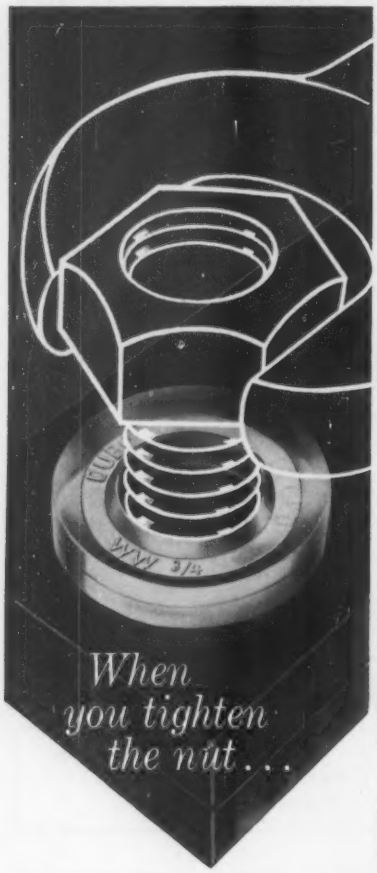
MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3669 JACKSON RD., ANN ARBOR, MICH.

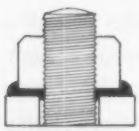
WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

Circle 424 on Page 19

This new lock and seal washer is just plain **REVOLUTIONARY...**



NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it . . . so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties . . . exceptional wear resistance . . . good shock absorption . . . resists corrosion, chemicals . . . non-flammable . . . high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

YOU'LL WANT COMPLETE TECHNICAL INFORMATION.

Write today to:

NYLOGRIP PRODUCTS

569 Pleasant St., Watertown, Mass.-WA 6-0100

Non Metallic Fastenings of all types.

Circle 425 on Page 19

ment of Management. Management Engineering Conference to be held at the Statler Hilton Hotel, New York. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

April 11-13—

Fourth Conference on Manufacturing Automation to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and *Automation* magazine. Further information can be obtained from K. E. Glancy, Div. of Adult Education, Purdue University.

April 12-13—

Institute of Radio Engineers. 14th Annual Spring Technical Meeting to be held in conjunction with the American Rocket Society at the Hotel Alms, Cincinnati, Ohio. Further information is available from IRE, 1 E. 79th St., New York 21, N. Y.

April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Sheraton-Cleveland Hotel, Cleveland. Additional information is available from conference publicity chairman, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

April 19-21—

American Society of Lubrication Engineers. Annual Meeting and Exhibit to be held at the Netherland-Hilton Hotel, Cincinnati. Additional information is available from ASLE headquarters, 84 E. Randolph St., Chicago 1, Ill.

"Tell me, Bullfinch—how do you keep that self-winding watch of yours going?"

April 20-22—

Institute of the Aeronautical Sciences. National Symposium on Manned Space Stations to be held at the Ambassador Hotel, Los Angeles. Further information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

April 21-28—

American Society of Tool and Manufacturing Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton-Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

May 3-5—

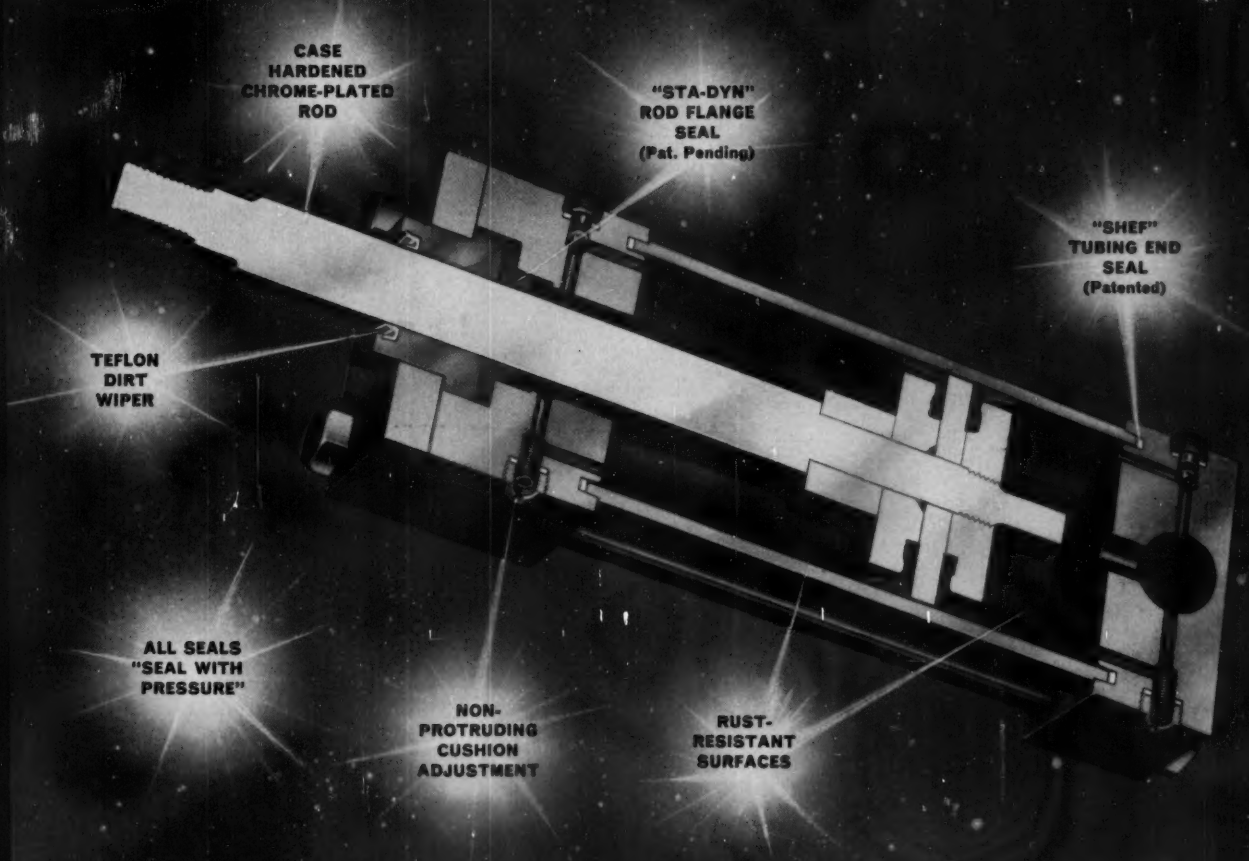
Western Joint Computer Conference to be held at the Jack Tar Hotel, San Francisco. Sponsors are Institute of Radio Engineers, American Institute of Electrical Engineers, and Association for Computing Machinery. Further information can be obtained from William C. Estler, 965 Lincoln Ave., Palo Alto, Calif.

May 9-13—

American Society for Metals. Second Southwestern Metal Exposition and Congress to be held in the Automobile Bldg., State Fair Park, Dallas. Additional information is available from ASM, Metals Park, Novelty, Ohio.

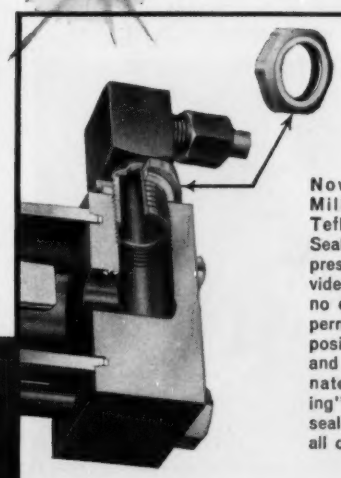
Circle 426 on Page 19→

Stellar RELIABILITY and ECONOMY


CASE HARDENED CHROME-PLATED ROD
"STA-DYN" ROD FLANGE SEAL (Pat. Pending)
"SHEF" TUBING END SEAL (Patented)
TEFLON DIRT WIPER
ALL SEALS "SEAL WITH PRESSURE"
NON-PROTRUDING CUSHION ADJUSTMENT
RUST-RESISTANT SURFACES

Miller AIR CYLINDERS

PORT SEALS



Now—with every Miller Cylinder—Teflon-sealed Port Seals that "Seal with pressure" are provided as standard at no extra cost. They permit much faster positioning of lines and fittings, eliminate "overtightening" damage, and seal perfectly against all operating media.

Here are eight more reasons why Miller Air Cylinders continue to be the most economical and reliable cylinders that money can buy. These stellar features—including the new port seals—are standard Miller construction—yours at no extra cost. Thus, they provide appreciable savings in original investment—*particularly for those who insist on "J. I. C." quality throughout.* Savings in operating costs are even greater, because these features are proven assurance of longer cylinder life, greater efficiency, reduced maintenance and downtime.

Specify "Miller" for greater reliability and economy! Write for bulletin.

MILLER FLUID POWER

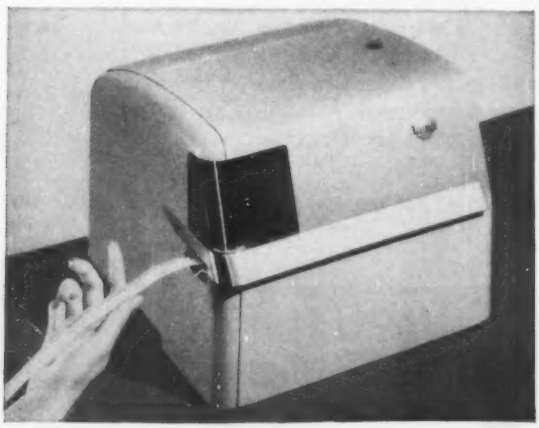
7NO16 York Road, Bensenville, Illinois

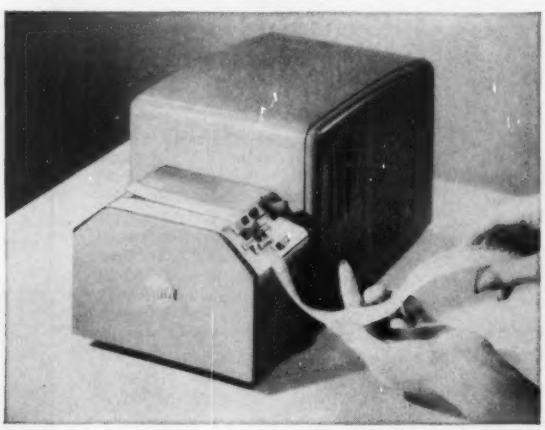
Teletype Model 28 Automatic Send-Receive Set A "complete station" in one console—with facilities for sending and receiving on message paper or sprocket-fed business forms . . . tape punching . . . sending or receiving with tape . . . integrating tape and manual keyboarding . . . producing tape automatically, as a by-product of send-receive operations.

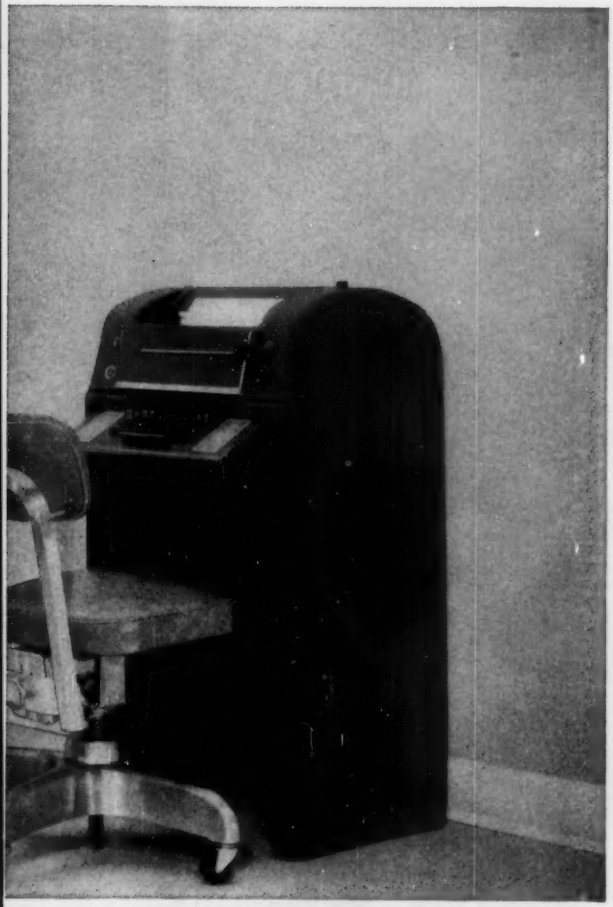
Teletype Model 28 Receive-Only Page Printer A message receiving unit (without keyboard). This is "terminal" equipment, for use where two-way communication is not necessary. No attendant is needed. Produces a printed record on plain paper or multipart business forms. Table models of this unit and the send-receive set at the right are also available.

Teletype Model 28 Tape Punch Receives incoming electrical signals, punches a 5-level "common language" tape, and prints data right on the tape, for easy identification and handling. Unit is used for message relaying . . . for integrating data from several sources into a single tape . . . for providing punched tape as a by-product of send-receive operations.

Teletype Model 28 Tape Reader This is a sending unit. Reads punched tape and instantaneously transmits data to local or remote receiving equipment. As with all Teletype transmitting units, data may go to one destination or a number of destinations simultaneously—either nearby or thousands of miles away.

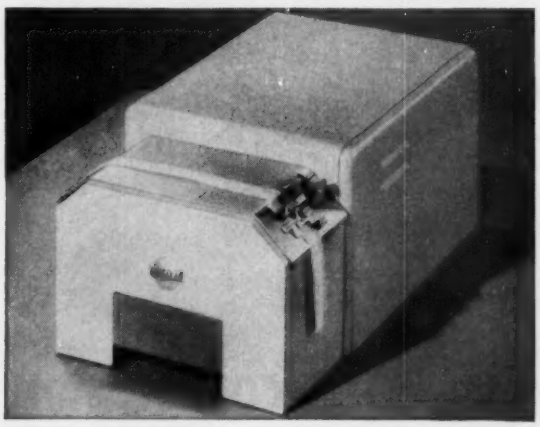






Teletype Model 28 Send-Receive Page Printer Message originating unit, for sending and receiving. Model 28 page units, including the Automatic Send-Receive Set, feature a built-in "stunt box" control system for automatic station selection and electrical control of remote equipment. Horizontal tabulation and form positioning arrangement available.

Teletype Model 28 Tape Reader—Twin Shaft Besides reading punched tape for on-line transmission, twin-shaft reader-distributor design offers facilities for simultaneous output on a multi-wire basis and direct translation (without tape) of signals from an external parallel-wire source for on-line transmission.



For your communications system . . .

TELETYPE Model 28 Line

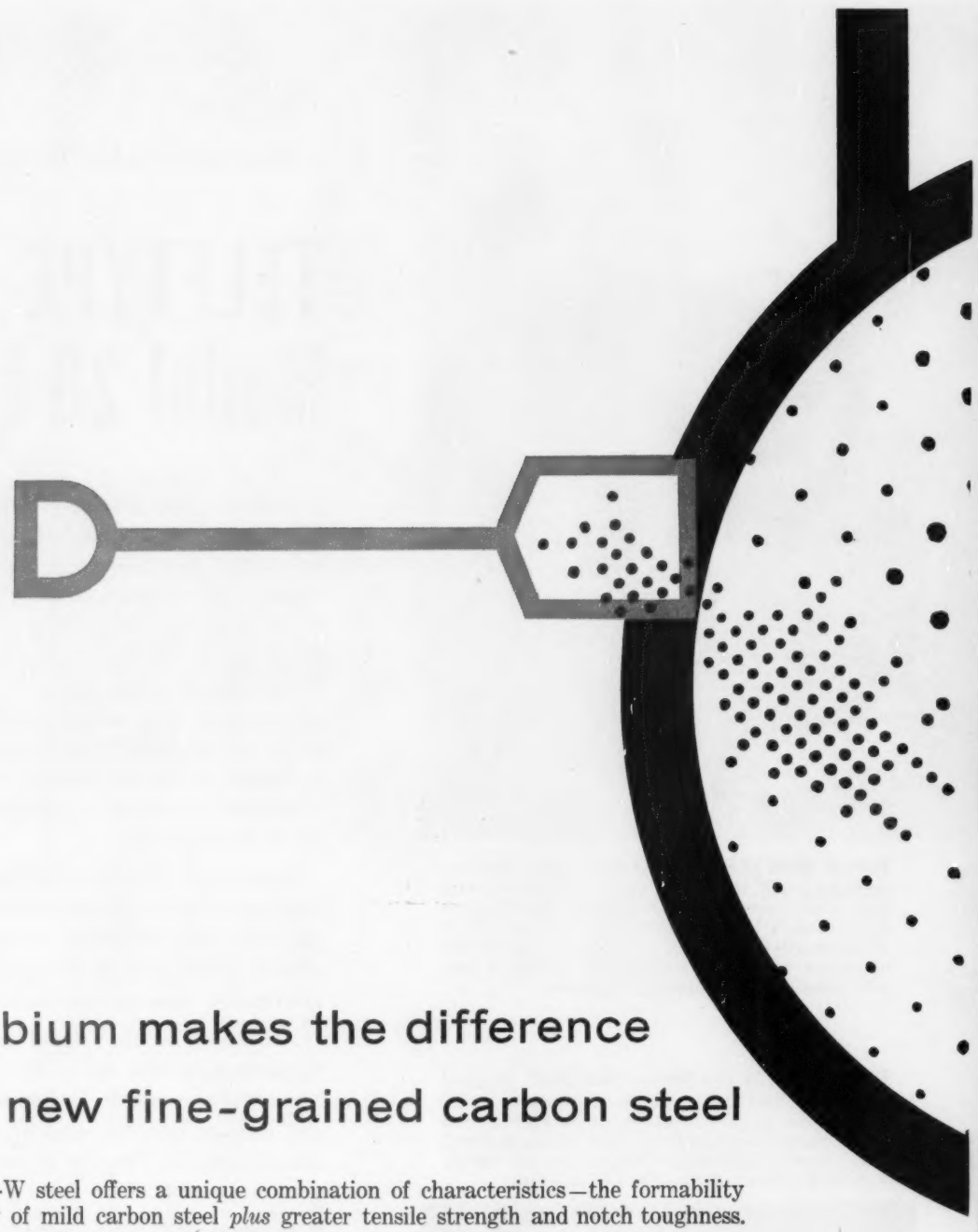
Presented here are the principal units of the Teletype Model 28 line. "Model 28" stands for an entirely new concept in record communications. It is an integrated line, designed on the modular principle, permitting a wide choice and ready interchange of components and providing accommodations for expansion. Typebox printing on page units makes possible quick interchange of alpha-numeric characters. Speed is 600 characters per minute with printing, up to 1,200 characters per minute on tape units where printing is not required.

These new machines are manufactured to Teletype's precision standards for continuous day-in and day-out service. All-steel clutches and simple harmonic-design elements greatly reduce and simplify maintenance requirements.

Exclusive with the Model 28 printer line is the versatile stunt box, which is actually a "robot brain." It responds to keyboard or line signals, and may be used for internal control of extra functions in the Teletype printer, as well as for external controls.

More information. If you would like more information on Model 28 equipment, please write to Teletype Corporation, Dept. *28B*, 4100 Fullerton Ave., Chicago 39, Illinois.

TELETYPE®
CORPORATION
SUBSIDIARY OF *Western Electric Company* INC.



Columbium makes the difference in this new fine-grained carbon steel

The new GLX-W steel offers a unique combination of characteristics—the formability and weldability of mild carbon steel *plus* greater tensile strength and notch toughness.

The addition of small amounts of columbium gives GLX-W the finer grain structure that makes this possible.

Where design permits, the use of GLX-W can result in weight savings up to 35%, compared with mild carbon steel. With yield strengths ranging from 45,000 to 60,000 psi, GLX-W steels are recommended for a broad range of applications. For technical information, write to our Product Development Division, Department MD-10.

GREAT LAKES STEEL
Detroit 29, Michigan

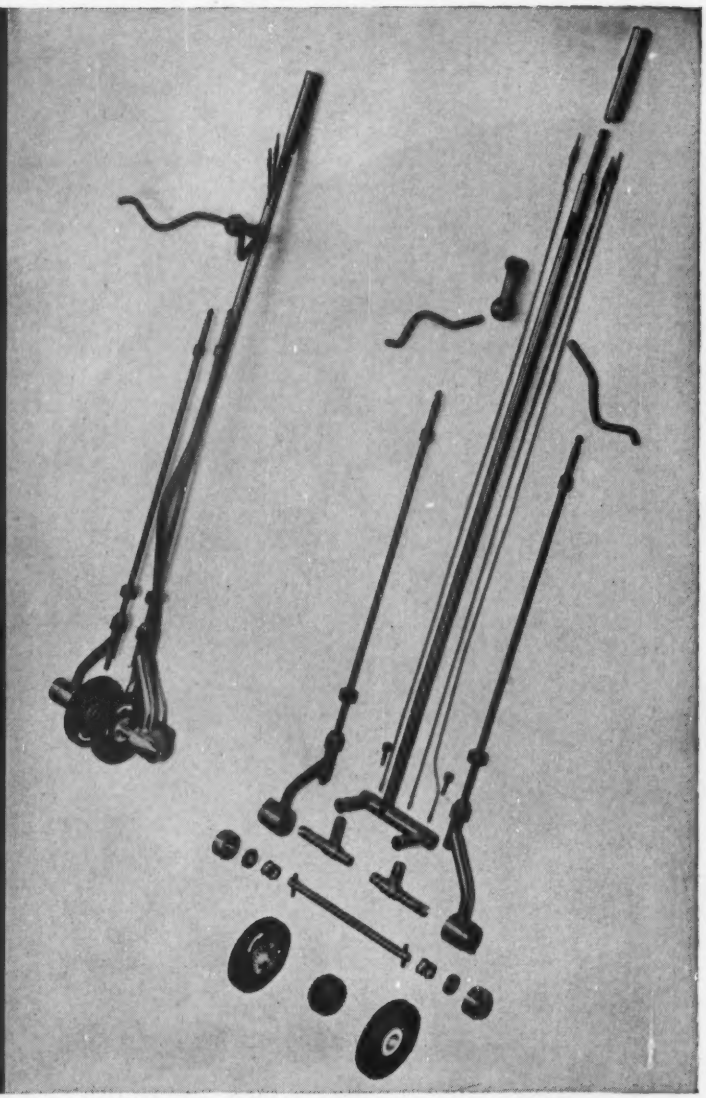
Great Lakes Steel is a Division of **NATIONAL STEEL CORPORATION**

GLX-W

Circle 428 on Page 19

HERE'S HOW STILL ANOTHER MANUFACTURER JOINS STAINLESS STEEL TUBING:

He uses Handy & Harman's BRAZE 630



He's one of many manufacturers and fabricators who have found—to their lasting satisfaction—that Handy & Harman silver alloy brazing is the final answer to stainless steel joining problems.

Super-Donic Manufacturing Company, Atlanta, Georgia, manufactures "Dual Arm Transmissions" for the dental industry. Most everybody has—at one time or another—seen and/or felt this unit in operation.

It is fabricated of small diameter 304 and 316 stainless steel tubing and, in its assembled form, consists of some 17 separate brazed joints. Joints must be strong, corrosion resistant and neat-appearing.

Each of the 17 joints is hand-torch brazed with Handy & Harman BRAZE 630 wire and HANDY FLUX TYPE B-1. There's no question that this is a unique application. There's no question, either, that the application is stainless steel. The ease and economy with which this manufacturer solves his problems can be just as readily applied to *your* stainless steel joining problems.

Strength, production speed, electrical and thermal conductivity, gas and liquid tightness and low cost are *natural* benefits of silver alloy brazing. We think it worth your while to learn more about this remarkable metal-joining method—we'll be glad to send you any information you ask for. Handy & Harman, 82 Fulton St., New York 38, N. Y.

FOR A GOOD START:
BULLETIN 20

This informative booklet gives a good picture of silver brazing and its benefits... includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

Your No. 1 Source of Supply and Authority on Brazing Alloys

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Circle 429 on Page 19

3 STOCK RELAYS for Day-In Day-Out Reliability

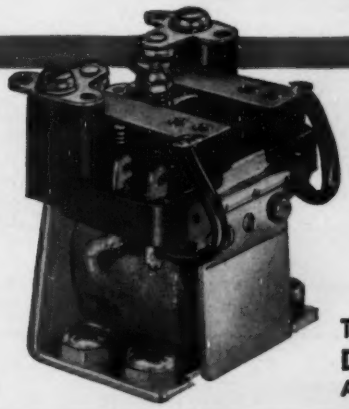
Type **DO** AC-DC

For Severe Shock and Vibration

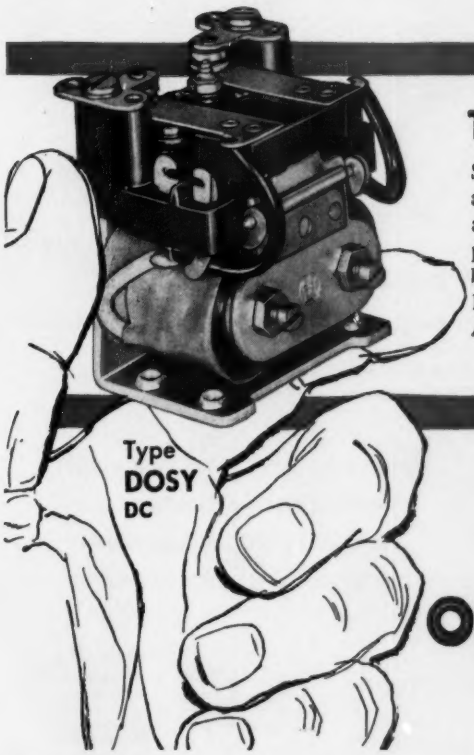
A rugged relay, particularly adaptable to aircraft and mobile applications. Design of molded parts around contact arms prevents mechanical injury. Available in twenty-three 3-pole and 4-pole types. *Coil Wattage:* 3.00 watts, DC operation; 6.00 watts, 60 cycle AC. Maximum temperature rise 45° C, DC; 75° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* 3-pole, approximately 5 ounces; 4-pole, 6 ounces.

Compact and Lightweight

A general-purpose relay of wide application. Handles loads usually demanded of much larger relays. Meets rigorous aircraft relay standards. Twenty single-and double-pole types. *Coil Wattage:* 2.5 watts, DC; 3 watts, 60 cycle AC. Maximum temperature 45° C, DC; 65° C, AC. *Coil Operating Voltages:* from 6 to 230 VAC (60 cycles) and 6 to 220 VDC. *Contacts:* Fine silver is standard. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4 ounces.



Type **DOS** AC-DC



Type **DOSY** DC

Twin Coils for Extra Sensitivity

Similar in construction to Model DOS. The DOSY relay is adaptable to a wide range of electronic applications such as plate circuit controls or as overload or underload controls in DC circuits to signal attainment of predetermined current levels. Four single- and double-pole types. *Coil Wattage:* 1.00 watt, with maximum temperature rise of 45° C. *Contacts:* Fine silver. Rated for 115 VAC or 32 VDC, non-inductive load. *Weight:* Approximately 4½ ounces.

Write for Stock Catalog 30

Also other quality relays of many types

RHEOSTATS • RESISTORS • RELAYS
TAP SWITCHES • R.F. CHOKES
VARIABLE TRANSFORMERS
TANTALUM CAPACITORS
GERMANIUM DIODES

OHMITE® QUALITY Components

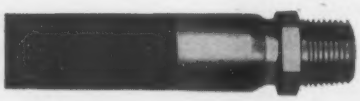
OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

Circle 430 on Page 19

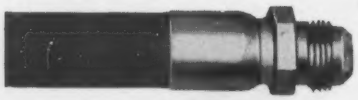
Eastman first to be specified by America's leading OEM's...

A COMPLETE LINE TO CHOOSE FROM FOR YOUR PARTICULAR APPLICATION

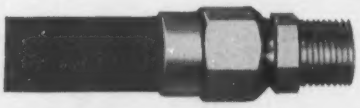
Available in all thread styles and sizes



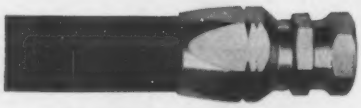
Permanently Attached Male (NPTF) for 1, 2 and 3 Wire Braid rubber cover hose. Plated to prevent rust and corrosion.
Sizes: ¼" thru 2".
Wkg. Press.: 375—5000 p.s.i.



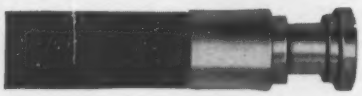
Permanently Attached Male Flare (JIC) for 4 and 6 Spiral Wire Braid rubber cover hose. Used for Ultra High Pressure.
Sizes: ½" thru 1½".
Wkg. Press.: up to 7500 p.s.i.



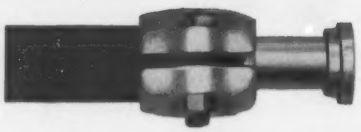
Reusable Male (NPTF) for cotton and rubber cover hose. No skiving necessary.
Sizes: ¼" thru 2".
Wkg. Press.: 350—3000 p.s.i.



Reusable Swivel Female for 1 and 2 Wire Braid rubber cover hose. Easy field replacement.
Sizes: ¼" thru 1¼".
Wkg. Press.: 375—5000 p.s.i.



Permanently Attached Flange Head Couplings for 1 and 2 Wire Braid rubber cover hose. Available in angles to 90°.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.



Clamp Type Couplings with split flange stems for 1 and 2 Wire Braid rubber cover hose. Exclusive "Inter-Lock" feature.
Sizes: ½" thru 2".
Wkg. Press.: 375—5000 p.s.i.

Permanently Attached Power Steering Assemblies to meet all requirements—designed to your specifications.

Permanently Attached Air Conditioning Assemblies for automotive use—designed to your particular specifications.

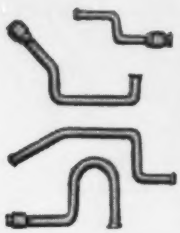
It's a known fact that many leading Original Equipment Manufacturers submit their original specifications for their *first* quotation to Eastman.

EASTMAN's unequalled experience in hydraulic conversion, plus many original designs shown in a few popular Eastman fittings at the left—give your product an appearance of quality that improves its competitive position. These assemblies are available in all thread styles and sizes.

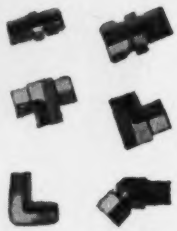
EASTMAN Engineering Service... Backed by Unequalled Experience

It is also a known fact that Eastman's co-operative engineering counsel and service is highly respected and often requested by leading OEM's. Let Eastman engineers help you lay out your fluid power lines—from pump to point of work—effecting economies in design, improving performance and increasing user satisfaction.

Let EASTMAN recommend the *best assembly . . . for the best performance . . . at the lowest cost.*



Bent Tubing with the necessary fittings to meet your own specific requirements.



Adapters, Adapter Unions and Boss "O" Ring Fittings. All types and sizes available.

FOR ADDITIONAL INFORMATION, WRITE EASTMAN MFG. CO., MANITOWOC, WISCONSIN OR PHONE: MURRAY 4-4495

Eastman *first in the field*

MANUFACTURING COMPANY
Dept. MD-2
MANITOWOC, WISCONSIN

WRITE for Eastman Technical Bulletins Nos. 100 and 200 on High, Medium and Low Pressure Hydraulic Hose Assemblies.

Circle 431 on Page 19

Circle 432 on Page 19→

working with

Du Pont Zytel®

one of Du Pont's versatile engineering materials

Simplify designs ...save money with molded parts of Du Pont ZYTEL® nylon resins

The outstanding properties of parts made of ZYTEL nylon resins have led to the creation of simplified, money-saving designs. Typical of such improvements is the new Scotch Brand cellophane tape dispensing machine. Here, molded gears and shafts of ZYTEL replace more expensive machined steel parts. The intricate components of ZYTEL are easily molded to close tolerances and possess high strength and excellent wear resistance. Because of the low coefficient of friction of ZYTEL, these new parts eliminate the need for bearings, giving smooth, lubrication-free operation while saving money. And the parts of ZYTEL are much lighter than those previously used. For more examples of how ZYTEL nylon resins save money and simplify designs, look on the following page.

Tape dispenser by Specialty Manufacturing Co. for Minnesota Mining and Manufacturing Co., both of St. Paul, Minneapolis. Components of ZYTEL *molded by Northwest Plastics, Inc., St. Paul, Minnesota.*

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
THROUGH CHEMISTRY

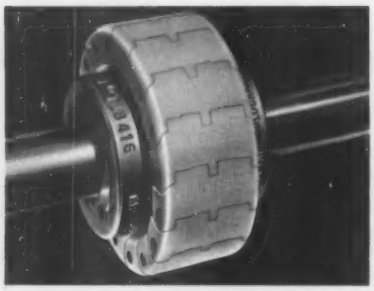
working with

Du Pont Zytel®

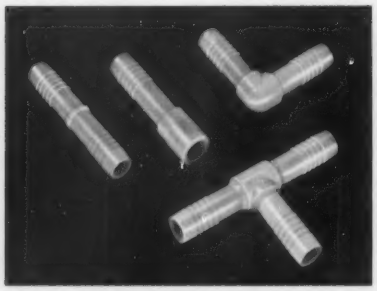
nylon resins

one of Du Pont's versatile engineering materials

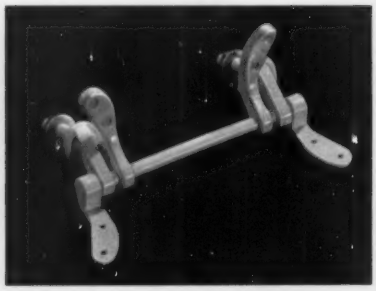
Complex moldings of ZYTEL® resist wear... corrosion... low temperatures



FLEXIBLE COUPLING made of links of ZYTEL outlasts metal chain coupling up to 6 to 1 and costs 20% less to buy and maintain. Coupling is clean, quiet, corrosive-free. (By Berea Plastics Co., Berea, O., for Morse Chain Co., Ithaca, New York.)



PIPE FITTINGS molded of ZYTEL are used to connect plastic pipe with plastic or metal pipe. Pressure grooving and threads are molded into the complex hollow shapes. The parts have high strength and chemical resistance. (By Yardley Plastics Co., Columbus, O.)



TOILET-SEAT HINGE made of ZYTEL is virtually indestructible . . . noncorrosive, rustproof . . . highly resistant to stain or discoloration. Easy-to-clean hinge never peels, cracks or chips. (By Bemis Manufacturing Corp., Sheboygan Falls, Wisconsin.)

When parts of any kind are subjected to rugged treatment, moldings of ZYTEL nylon resins usually give longer wear at lower cost. Because of an unusual combination of properties, parts of ZYTEL are equipped to withstand conditions that would reduce the life of ordinary materials. ZYTEL is easily molded into complex shapes and has exceptionally high strength in thin sections. Its resistance to temperature extremes allows reliable use under such conditions. Resisting corrosion, ZYTEL is ideal for use requiring exposure to the elements or to chemicals. Light in weight, it resists abrasion and impact. Du Pont ZYTEL may help you save money by reducing production costs and giving improved performance under adverse conditions. Find out how by filling out and sending in the coupon below.

POLYCHEMICALS DEPARTMENT

DU PONT

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Better Things for Better Living... *through Chemistry*

E. I. du Pont de Nemours & Co. (Inc.), Dept. 123
Room 2507Z, Nemours Building, Wilmington 98, Delaware.

Please send me more information on Du Pont ZYTEL. I am interested in evaluating this material for:_____

_____

Name_____ Position_____

Company_____

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Type of Business_____

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

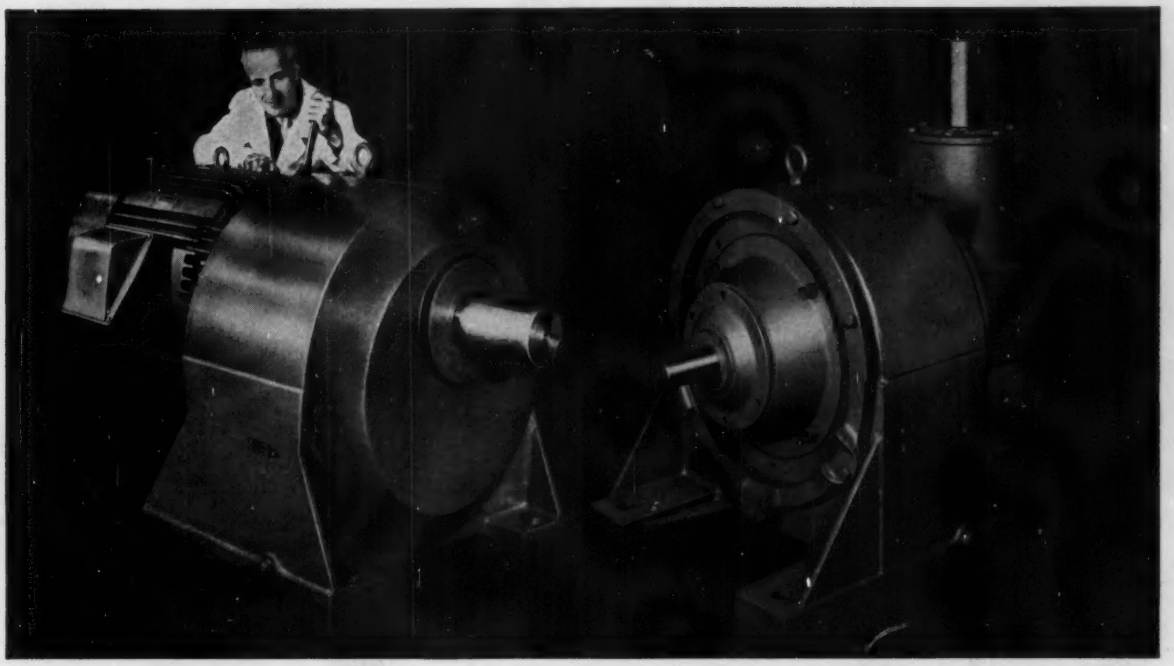
ZYTEL® *nylon resins*

one of Du Pont's versatile engineering materials

Alathon® · Delrin® · Lucite®

NOW...high horsepower Gearmotors and In-Line Reducers that weigh less, have increased load carrying capacity

The gearing in these drives is case hardened and precision ground, a development so advanced that conventional standards and ratings are suddenly out-of-date. You get commercial gear drives with gearing of master gear quality, plus a whole new set of engineering advantages. They are available in standard sizes to 200 H.P.



(Left) 75-HP GEARMOTOR.
Application: heavy duty machine tool drive.

(Right) 50-HP IN-LINE REDUCER with right angle attachment.
Application: conveyor drive.

LONGER LIFE

Extreme accuracy of tooth profiles, profile spacing and surface finish eliminates "running in" and resulting gear wear.

HIGHER SPEEDS

Dynamic load factors are reduced. Reducers operate at higher speeds, have increased load carrying capacity.

REDUCED VIBRATION

Reduced tooth to tooth errors, accumulated pitch errors and total composite errors give smoother contact.

SPACE AND WEIGHT SAVINGS

Harder materials, plus major reductions in load factors, save weight and space without sacrificing performance.

REDUCED SOUND LEVELS

For applications where low sound levels are important, gear noise is no longer a controlling factor.

100% INTERCHANGEABILITY

Duplicate units or spares can be installed with original manufacturing tolerances duplicated exactly.

Write today for catalog GM-60

philadelphia gear drives

PHILADELPHIA GEAR CORPORATION

King of Prussia (Suburban Philadelphia), Pennsylvania

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

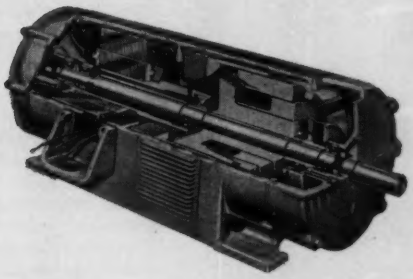
INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

←Circle 432 on Page 19

Circle 433 on Page 19

What do you need in an adjustable speed drive?

7½-hp Ajusto-Spede Drive



Common motor-drive housing for units up to 7½ hp saves space — can be foot or flange mounted. Larger sizes up to 100 hp with individual motor and drive housings mounted integrally.

NEW design news from Louis Allis

...The Louis Allis AJUSTO-SPEDE® drive is more compact, precise, and trouble-free

Here's an adjustable speed drive that allows *truly precise* machine operation. Speed regulation is automatic and stepless — results in faster, more efficient production at lower cost, with less waste, and minimum wear on equipment.

These and other benefits are yours when you use the improved Louis Allis Ajusto-Spede drive. For example, it can be set before or during operation to deliver any desired speed within its range. Its *exclusive* tachometer feedback circuit monitors the output speed and *automatically corrects speed and holds it* regardless of load changes.

This improved drive requires minimum maintenance. Its stationary field has no brushes, commutators, or slip rings to cause trouble. The source of power is an equally trouble-free standard a-c squirrel cage motor. The cast-iron housing keeps out dirt, chips, and moisture — resists corrosion.

The compact Ajusto-Spede also saves space. Integrally-mounted motor and drive simplify handling — can be easily adapted for installation on new or existing machines. Controls can be mounted at the machine or any other convenient position.

The Louis Allis Ajusto-Spede drive is the practical solution to almost every application that requires dependable, easily controlled adjustable speed. It is the answer to precise operating speeds for machine tools, process machinery, test equipment, windups, conveyors, printing presses, and other equipment. Contact your Louis Allis District Office for information and application help. Or write for bulletins 2750 and 2800 — The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

® *Ajusto-Spede is a registered trademark of the Eaton Mfg. Co.*

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

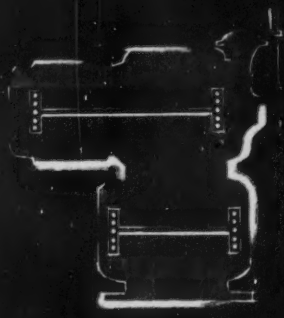
LOUIS ALLIS

ASD-127

Circle 434 on Page 19

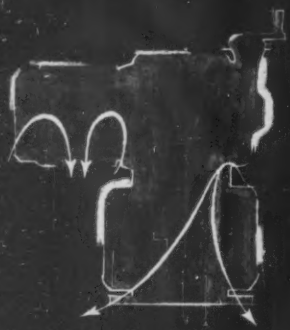
Field Versatility

Mounting feet, end brackets, control hand wheel, conduit box, and output shaft can be relocated in minutes without special tools for wall-, floor- or ceiling mounting. Components can be changed or controls can be added in the field to meet ever changing conditions of operation.



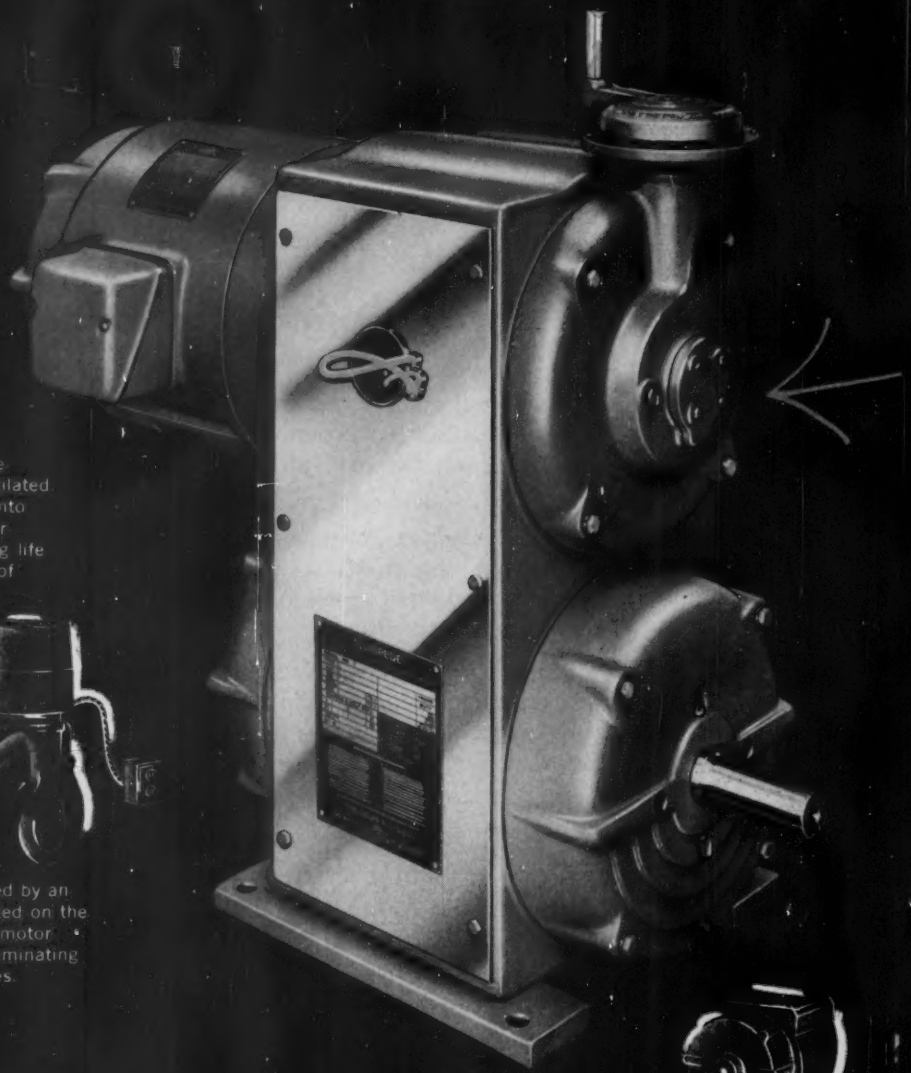
Four-Bearing Design

This important design feature eliminates the problems of overhung discs. It equalizes distribution of belt loading,— keeps bearings, shafts, discs and belt permanently aligned — improves performance — and extends bearing life.



Dual-Ventilation System

The motor and the belt housing of the ALLISPEDE DRIVE are individually ventilated. Motor ventilating air is not exhausted into the belt housing — belts run cooler for longer life. Service factor and operating life of all components are higher because of lower operating temperatures.



Trouble-Free Remote Control

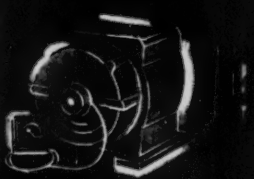
Electrical remote control can be provided by an enclosed speed adjusting motor, mounted on the belt changing mechanism. This torque motor can be stalled without overheating, eliminating the need for troublesome limit switches.

Long Belt Life

Single cog belts with extra contact area provide more efficient transmission of power and longer belt life. Dual ventilation, precision-machined discs, equalized loading, and automatic belt tension aid in extending belt life.

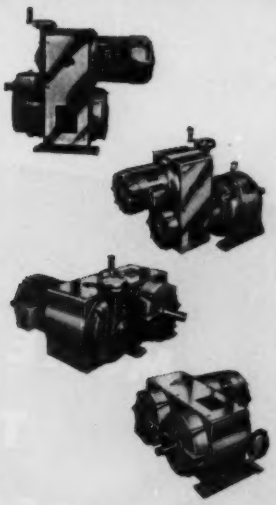
Fast Belt Changing

Belt changing is fast and easy — without requiring special tools. You remove only one bearing bracket and the speed-adjusting mechanism to make fast changes without affecting permanent alignment of discs or belts.



Remote Speed Indication

A tachometer generator mounted on the output shaft operates an indicator that can be mounted at a remote location. Disassembly of the tachometer is not required when making belt changes.



Four of the many variations of mounting available with the ALLISPEDE DRIVE.

Another new product from Louis Allis

Let's look at the features of the ALLISPEDE DRIVE*

New Louis Allis Drive offers accurate control – maximum belt life – long-run economy – low-cost versatility – ease of installation

After checking the many superior features of this drive, you will prefer the Allispede every time. The illustrations at the left demonstrate the many advantages of design and construction available in this drive.

The Allispede Drive gives you high efficiency and close regulation. Belt tension adjusts automatically — and belt changes are easy and fast. The modern design eliminates overhung discs—maintains belt and disc alignment — results in longer belt life — provides the ultimate in field versatility.

Check the accompanying features — *now!* A phone call to your local Louis Allis District Office will bring a skilled Louis Allis Field Engineer. He will gladly study your drive problem and offer Application Engineering assistance. Or write to Louis Allis Company, 459 East Stewart Street, Milwaukee 1, Wisconsin for a copy of Bulletin 3600.

*ALLISPEDE is a trademark of The Louis Allis Company.

The Complete Line–

Whatever your mechanical drive application requirements, there's an ALLISPEDE DRIVE to match it exactly. Sizes up to 30 HP, output speeds from 1 to 10,000 RPM, and speed ranges up to 8:1. Motors can be open, drip-proof, enclosed, or explosion-proof; with ventilated or enclosed belt housings, suitable for foot, P-base, C- or D-flange mounting on your machine. Available with parallel shaft, or right-angle, integral gear reducers, special shaft extensions, integral magnetic brakes, electrical or mechanical remote control, and other modifications as required to meet the specifications of your application.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 435 on Page 19

A59-131

DODGE HAS MORE PROVED BEARINGS THAN YOU HAVE BEARING PROBLEMS!

It pays to buy from a line of stock bearings—bearings that have been proved in thousands of installations similar tc yours. You benefit by getting known dependability; and you get the important savings of high quality at production price.

PIN-POINT SELECTIVITY

Dodge has supplied mounted bearings to industry for over three-quarters of a century. Dodge bearings have always kept pace with improved production practices. Each new condition of service has been met by Dodge as it has arisen, with the result that the Dodge line contains mounted bearings to meet almost every service requirement with pinpoint accuracy.

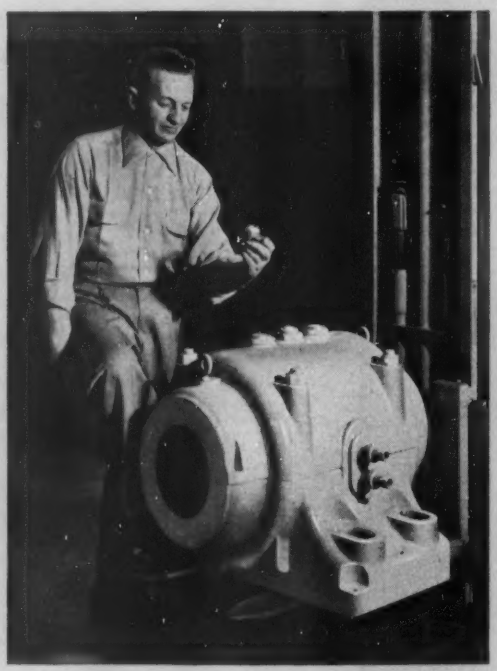
High load, high speed, excessive dust, moisture, corrosion, high or low temperatures, continuous operation—you name it!—such conditions and their combinations are met every day with Dodge bearings.

BROAD LINE—WIDELY DISTRIBUTED

In the great variety of mounted bearings developed by Dodge, you will most likely find the precise unit to fit your requirements ideally—without paying for features you do not need. And if your requirements call for several types of bearings, there is an advantage in having them of common design, such as Dodge offers.

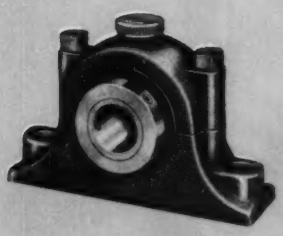
The Dodge line is probably broader than any other line of mounted bearings in America. And of special importance to machinery manufacturers, it is the most widely distributed line. There is always a Dodge bearing of the right type and size near at hand.

You can check this with your local Dodge Distributor. Ask him—or write us for the Dodge Bearing Bulletin.

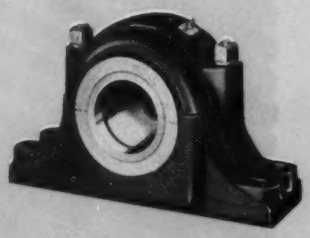


In addition to tapered roller, spherical roller and ball bearings, Dodge builds many types of sleeve bearings. Here is the "large and small" of the sleeve type bearings carried in stock—ranging from an 8-in. Sleevoil weighing over 1200 lbs. to a ½-in. solid journal bearing weighing 9 ounces.

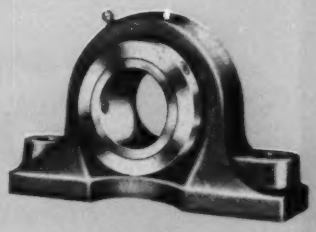
DODGE MANUFACTURING CORPORATION, 3300 Union Street, Mishawaka, Indiana



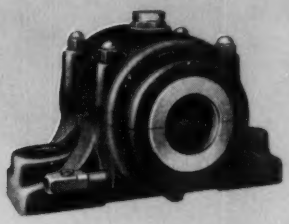
DODGE PILLOW BLOCKS WITH TIMKEN TAPERED ROLLER BEARINGS



DODGE SPHER-ALIGN PILLOW BLOCKS WITH SPHERICAL ROLLER BEARINGS

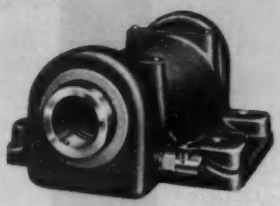


DODGE BALL BEARING PILLOW BLOCKS

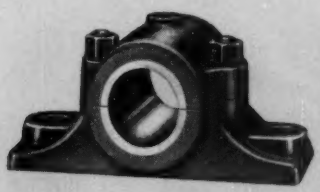


DODGE SLEEVOIL PILLOW BLOCKS

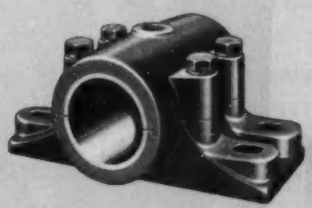
DODGE BRONZOIL PILLOW BLOCKS



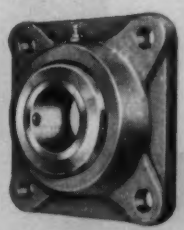
DODGE BRONZE BUSHED PILLOW BLOCKS



DODGE JOURNAL BEARINGS SOLID AND SPLIT



DODGE HEAVY RIGID PILLOW BLOCKS



FLANGE BEARINGS: HANGER BEARINGS: BEARING UNITS: TAKE-UPS

● **Dodge Pillow Blocks with Timken Tapered Roller Bearings.** America's quality pillow blocks. Assembled, lubricated, adjusted and sealed at the factory. 5 types for varying needs.

● **Dodge Spher-Align with Spherical Roller Bearings.** Rugged heavy duty, compact, inherently self-aligning. Exclusive Micro-Mount simplifies installation.

● **Dodge Ball Bearing Pillow Blocks.** Deep groove ball bearings with long inner races—high capacity. SL, SC and SCM models for light, normal and medium service respectively.

● **Dodge Sleevoil Pillow Blocks.** Ultra quality . . . extra long life . . . accessibility . . . *quiet*. Plain or water-cooled.

● **Dodge Bronzoil Pillow Blocks.** Efficient, low cost pillow blocks with self-oiling, capillary bronze bushings. Self-aligning. Large oil reservoirs.

● **Dodge Bronze Bushed Pillow Blocks.** Quiet fan and blower pillow blocks with two bronze bushings of high lead content mounted in one cast iron housing.

● **Dodge Journal Bearings — Solid and Split.** True running, dependable. Babbitted bearings with precision machined bores and faces. Finished bases.

● **Dodge Heavy Rigid Pillow Blocks.** Rugged, carefully bored, babbitted pillow blocks for many applications requiring grease lubrication. Finished bases and ends.

● **Bearing Units.** A wide variety—spherical seat, cartridge, flange, hanger, screw conveyor hanger, take-up. Ball, Roller and Sleeve types.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

DODGE

of Mishawaka, Ind.

Circle 436 on Page 19

NICHOLSON
U.S.A.

Good to the last bite . . .

Nicholson files and rasps, manufactured by the Nicholson File Company of Providence, Rhode Island, are regarded by tool experts as among the finest in the world. A long history of experience and research has taught Nicholson craftsmen how to make good, long-lasting products.

In file or rasp-making, preparation of the steel is paramount. After precision forming, the steel is carefully heat treated to develop uniform internal grain structure. A reciprocating chisel cuts the teeth, then the file or rasp is heated in a lead bath and quenched to develop hardness. It is cleaned and sharpened by sandblasting, the tang is heat treated to improve toughness, and the file is finally inspected.

U.S.Steel metallurgists have worked closely with Nicholson's designers to provide just the right special-purpose steel for each special-purpose file or rasp. Just as there is no one all-purpose file or rasp, steels, too, are made with an almost countless variety of physical and chemical properties. Every day U.S. Steel produces "special purpose" steels, with a chemistry to meet a designer's specific requirements. As the Nicholson File Company knows, "steel" is not a single product. It is an almost limitless array of practical solutions to the problems of the most imaginative and demanding designer. U.S. Steel research is available at all times to help you get a job done right. United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

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United States Steel

DEPENDABILITY of shifter fork improved by designing it to be FORGED

Modern board forging hammer

By designing the shifter fork of his transmission to be forged, a manufacturer of earthmovers eliminated costly equipment breakdowns in the field because of fork failure. Factor of safety was *in*creased even while weight and over-all costs were being *de*creased.

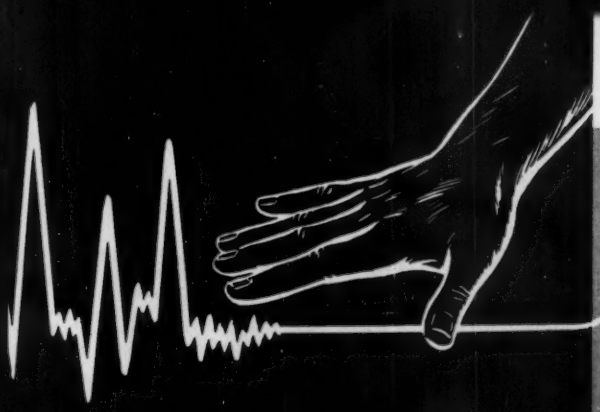
Parts scrapped because of voids uncovered after much high-cost machining are eliminated . . . forgings are *naturally* sound all the way through. Forgings start as *better* metal . . . are further *improved* by the compacting hammer-blows or high-pressure of the forging process.

Design your parts to be forged . . . increase strength/weight ratio, reduce as-assembled cost, improve performance. Literature to help you design, specify, and procure forged parts is available on request.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine



ROBINSON

Vibration and Shock Control

PROTECTS PERFORMANCE

and assures RELIABILITY in Vital Weapons Systems

for

missiles

Robinson all-metal MET-L-FLEX® mounting systems are ***now*** protecting certain components and items of sensitive equipment installed in the Atlas, Titan, Polaris, Bomarc, Lacrosse and other important missiles. Advanced space projects will depend heavily upon the specialized engineering resources that are available at Robinson to achieve reliability through environmental control.

aircraft

Today every major commercial and military aircraft including intercontinental and medium range jet bombers, supersonic fighter-bombers and interceptors, trainers, tankers, cargo and reconnaissance planes, are equipped with all-metal mounting systems designed by Robinson to protect many vital components.

surface ships and submarines

Robinson pioneered in the development and production of new ***low frequency*** shipboard mounting systems for the Navy's new single sideband communications equipment. These all-metal mountings have been specified by the Navy for installation in nuclear submarines and surface craft.

vehicles

Rugged, all-metal mounts have been designed, tested, and accepted to protect the latest communications and electronic equipment installed in tanks, trucks, jeeps, command cars, and other military vehicles. The operational life of the electronic components will be extended and reliability increased.

VIBRATION CONTROL IS RELIABILITY CONTROL

ROBINSON *Technical Products Inc*

TETERBORO, N. J.

Formerly ROBINSON AVIATION INC. • West Coast Engineering Office: Santa Monica, Calif.

DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS

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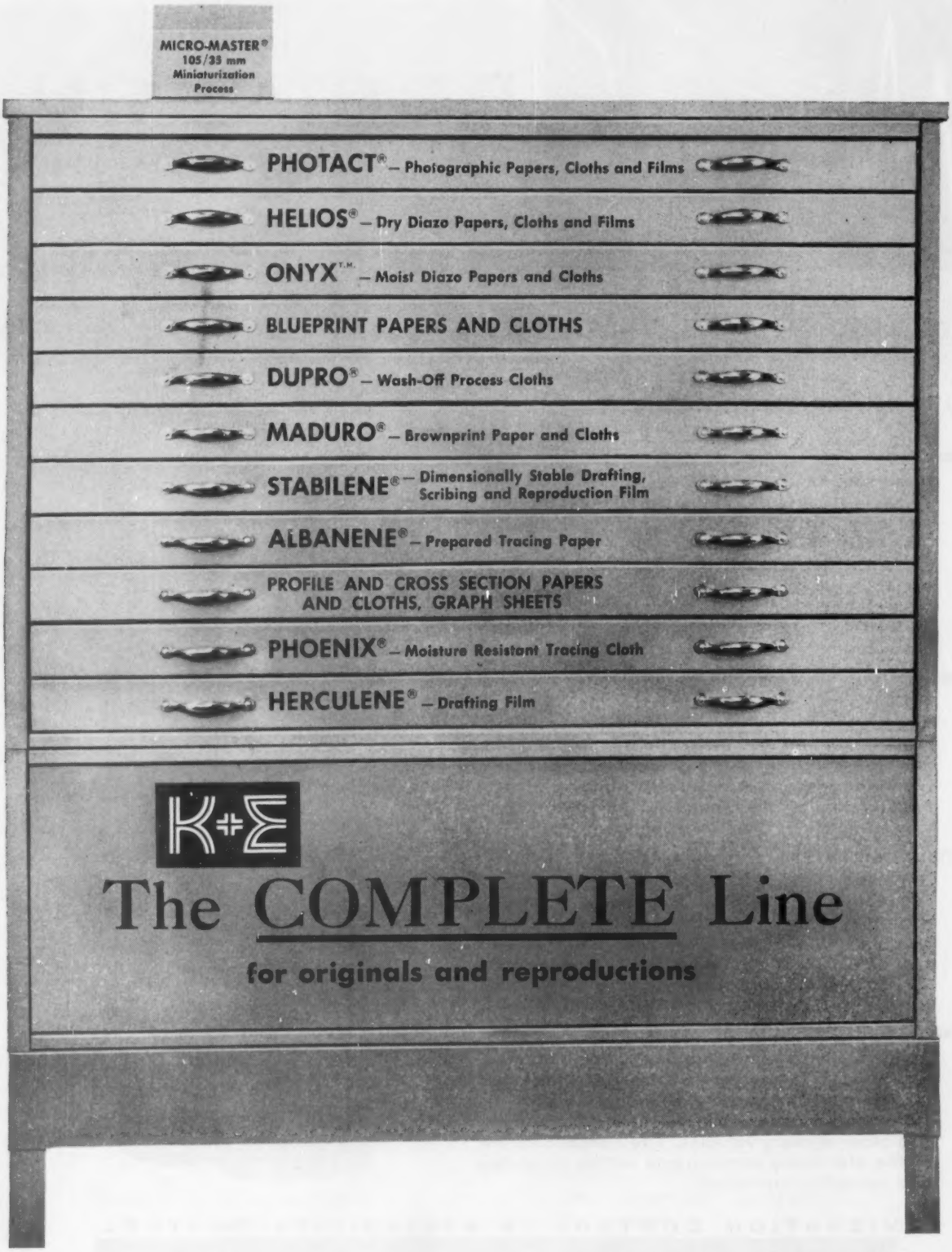
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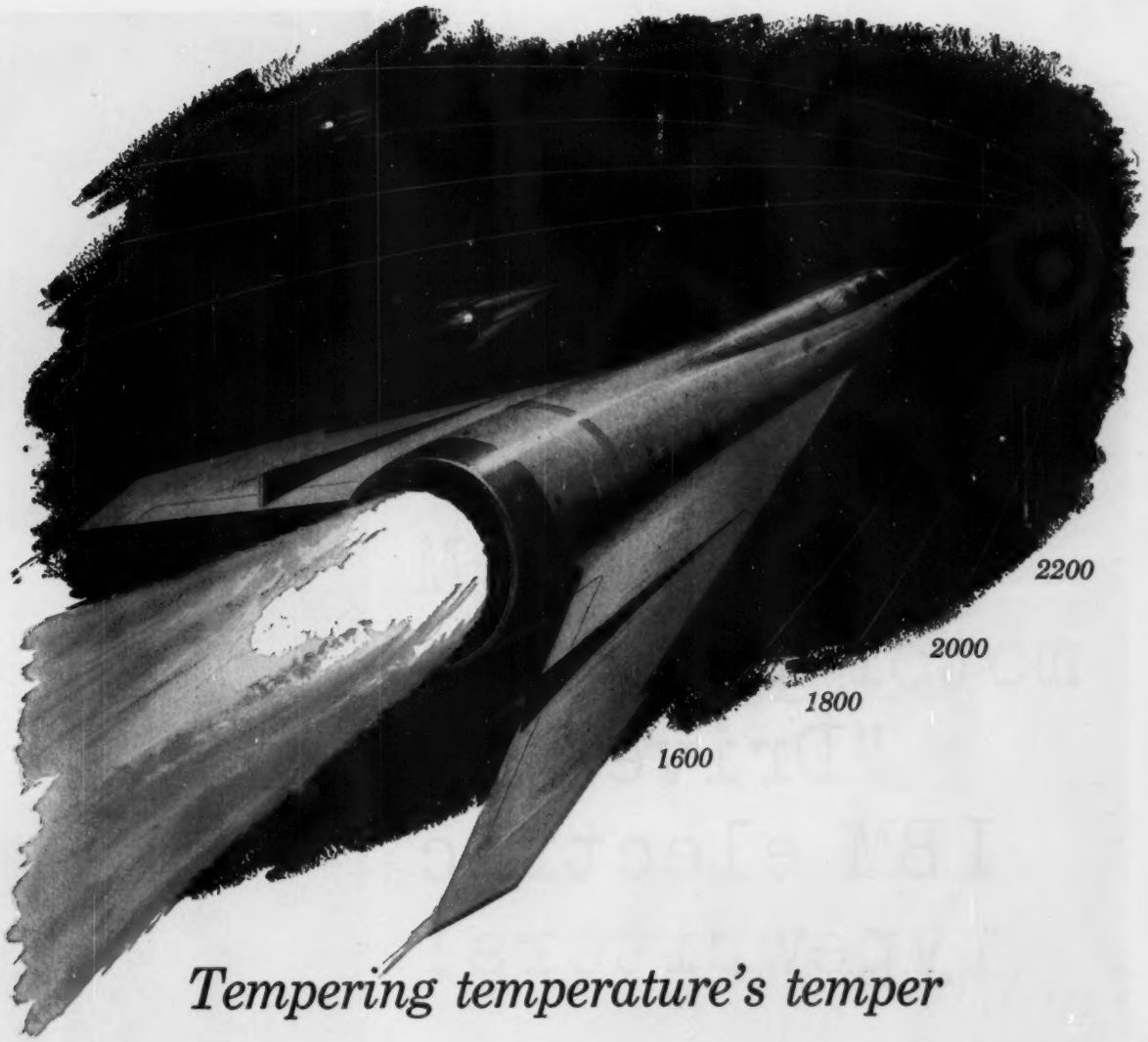
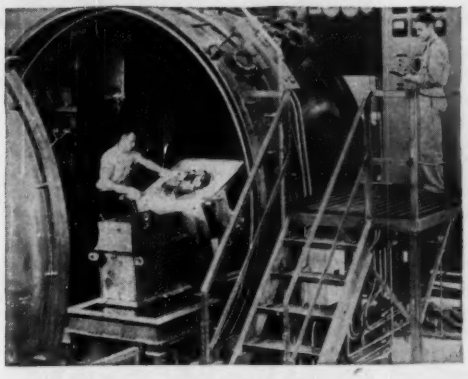


Tempering temperature's temper



Complete vacuum melting equipment is part of HAYNES STELLITE's modern plant facilities. For full details, write for 48-page descriptive booklet.

Heat of 2000+ deg. F. is generated in a supersonic jet's tailpipe. So is extreme vibration.

By far the best alloy tested for this critical component is MULTIMET alloy—one of 12 HAYNES alloys helping combat heat, stress, and erosion in the jet engine, missile, and rocket field.

HAYNES alloys are relied on for use in afterburners, turbine blades, nozzle vanes, and many other high-temperature parts. All 12 HAYNES high-temperature alloys are *production* alloys and are readily available. Some are vacuum melted. Some air melted. Some are cast, some wrought, some are produced in both forms.

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 420 Lexington Avenue, New York 17, N. Y.

"Haynes," "Multimet," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

this R & M motor puts the "Drive" in IBM electric typewriters!

Almost twelve years have elapsed since International Business Machines Corporation used its first R&M motor to power its electric typewriters. Since then R&M has supplied thousands upon thousands of these special motors for IBM's world-wide typewriter trade. In order to meet varying electrical conditions the world over, they are now supplied in 21 different voltages and frequencies.

IBM proposed strict requirements for powering their machine. The motor must have high starting torque for quick response . . . run very quietly . . . cooler than normal . . . fit a limited space . . . and have stamina to perform dependably year after year. Within a short period of time, R&M delivered specifications for the right design—a dynamically balanced motor that fulfilled all of IBM's standards, including reliable operation that covers thousands of hours between check-ups.

A lot of fingers have gone over the keys since R&M produced its first IBM typewriter motor, but we still subject each IBM power unit to 100% inspection. Moreover, we constantly work with IBM—and all our customers—to improve our motors and to adapt them to the ever-changing requirements of customers' products.

R&M's experience in custom-designing motors for hundreds of products, and our facilities to produce a design at low cost, are at your service. Perhaps your problem can be met with a standard *"off-the-shelf"* power unit. If so, we'll tell you . . . and recommend the right R&M motor for the job. For power by either custom or standard fractional HP motors . . . and performance that will give you a big competitive advantage . . . get in touch with Robbins & Myers today! Write for Bulletin No. 450-MD

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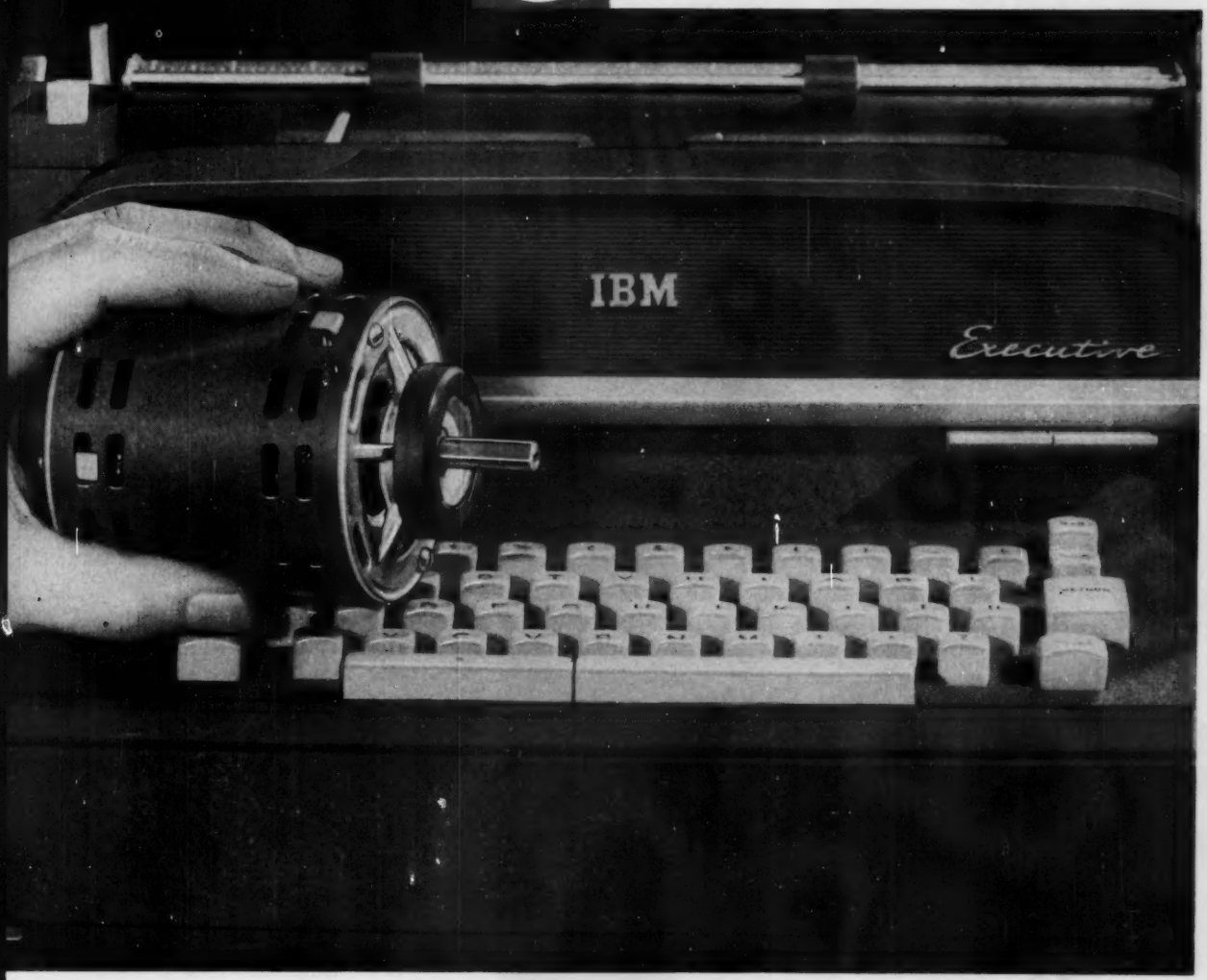
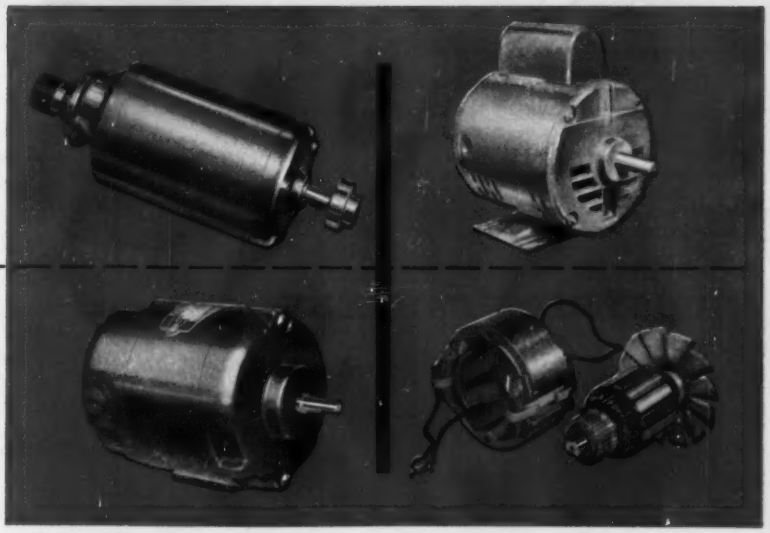
MOTORS 1/200 thru 1 HP

(other ratings up to 200 horsepower)



At left, Retractable Capstan Motor . . . shaft of this special R&M fractional HP motor rotates and also moves axially. Manufactured for IBM's 727 Magnetic Tape Unit.

At right, Standard Fractional HP Motors . . . a wide range of types, sizes and mountings for DC, single or polyphase AC; all standard voltages and frequencies.



At left, Standard Universal Motors . . . ratings from 1/50 to 1/2 HP. Choice of end, pad or foot mountings to permit design versatility. Custom designs also available.

At right, Series Motor Parts . . . precision-made series, universal or polyphase high-cycle motor parts. All types and sizes engineered to your requirements.

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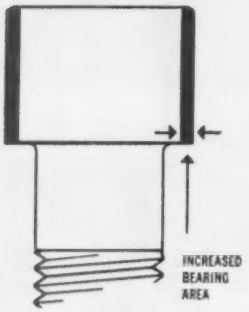
Up to 2⅓ times as much holding power!
Up to 100% longer fatigue life!

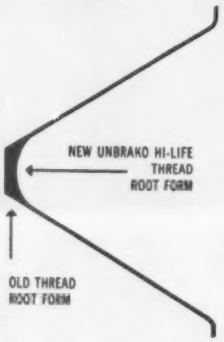
New UNBRAKO *pHd** Hi-Life socket screws —the advanced-design fastener for the 60's

Stronger in the head



New pHd head features increased bearing area, more powerful wrenching socket; provides up to 2½ times as much clamping force without indenting bolted material. This permits higher preloading, which in turn helps prevent fatigue failures or loosening under vibration.

Stronger in the thread



Smoothly radiused root of new Hi-Life thread distributes stress concentrations at point where 85% of screw failures occur. Elimination of sharp root corners practically doubles fatigue life, yet new thread fits standard tapped holes and nuts, requires no special gaging.

Here is the one new socket head cap screw that is redesigned *throughout*. UNBRAKO pHd Hi-Life is the only standard socket screw offering you both the new, larger pHd head (1960 Series) *and* new UNBRAKO Hi-Life thread—a combination unequaled for strength and performance.

Because of its increased bearing area under the head, you can tighten a pHd Hi-Life tighter without indenting the bolted material. This safeguards vital preload; protects against loosening under shock or vibration. At the same time, the new Hi-Life thread form drastically reduces stress concentrations at the root, where the majority of screw failures occur. Result: up to 100% increase in fatigue life.

Both the pHd head and Hi-Life thread originated in the SPS laboratories for advanced fastener research where they were first developed for ultra-high-strength aircraft bolts. Recognizing the critical need for increased mechanical reliability in industrial and consumer goods as well, SPS now offers these refinements in a standard commercial fastener. Price? The same as previous UNBRAKOS. Availability? Immediate—in sizes ¼ through 1 inch. See your authorized industrial distributor or write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium. Request Bulletins 2406, 2577.

TENSION-TENSION FATIGUE TESTS PROVE LONGER FATIGUE LIFE OF UNBRAKO HI-LIFE THREAD FORM

Screw Size: ½-20 Testing Speed: 1050 cpm

Alternating Stress in psi (000 omitted)	Cycle Life: Old Thread Root Form	Cycle Life: UNBRAKO Hi-Life Threads
2-20	2,076,000	8,000,000*
3-30	598,000	1,808,000
4-40	120,700	232,350
5-50	56,650	89,950
7-70	22,900	40,000

*Test stopped—no failure

INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA **SPS**

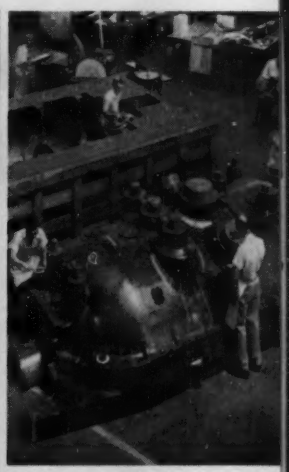
where reliability replaces probability

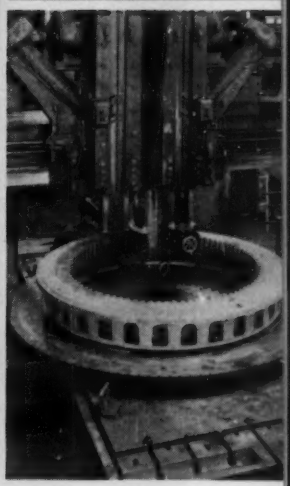
*pHd stands for "proper head design"—a factor in higher product reliability

Circle 442 on Page 19

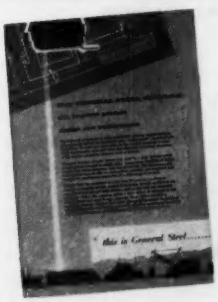
Circle 443 on Page 19→

...where industrial progress is cast in steel





PRODUCTION FACILITIES... COMPLETE AND MODERN



Write for folder: **How General Steel Castings Can Improve Product Design and Performance.** General Steel Castings, Station 260, Granite City, Illinois.

General Steel's large plants have complete facilities for producing, testing and machining castings to your specifications. Here are the facilities needed for quality production to suit your specialized requirements in cast steel structures . . . and steel castings used in cast-weld and composite structures.

Each plant maintains its own pattern, core making and molding departments, staffed by skilled craftsmen. Melting facilities capable of producing the correct steel for castings weighing up to 100 tons are complemented by the most modern foundry equipment available. Modern cleaning and finishing equipment, extensive heat treating facilities, specialized machine tools and the latest in non-destructive testing . . . radiographic, magnetic particle and ultra-sonic inspection devices . . . complete the picture.

General Steel's services range from application analysis before the product is designed to field service after the product is in use. Let us demonstrate how cooperative teamwork can make all this skill and knowledge available to you.

GENERAL STEEL CASTINGS

GRANITE CITY, ILL. • EDDYSTONE, PA. • AVONMORE, PA.

NEW! DUAL TORQUE-LOCKING AND POSITIONING DEVICE

REV-LOK eliminates feedback torque, provides two-directional positioning, drive, over-running and backstopping

NOW! You can have positive and instantaneous stopping of feedback (reverse) torque—it will never reach the driving equipment. For, the complement of sprags in this new Formsprag device is divided into two opposing sets that: instantly stops feedback from either direction, assures equalized radial loading, evenly distributes wear for longer life, and provides multi-contact surfaces for greater holding strength when high feedback torque occurs.

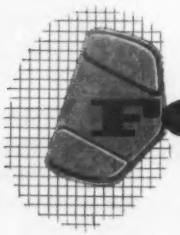
When the device is mounted with the outer race in a fixed position, feedback is stopped by wedging of sprags between output member and I.D. of fixed outer race—feedback never reaches the input shaft. Yet, this new design permits free rotation and transmission of high driving torque in either direction from input to output shaft.

When used as a two-directional over-running clutch, output shaft member is mechanically secured against rotation and outer race then becomes the output member. A slight right or left rotation of input shaft disengages either set of sprags and determines direction of drive, over-running and backstopping.

This versatile device can also be used for two-speed drive and reversing applications. By connecting a low-speed reversible motor to outer race and a high-speed motor to input shaft member, driving torque can be transmitted at two speeds or reversed.

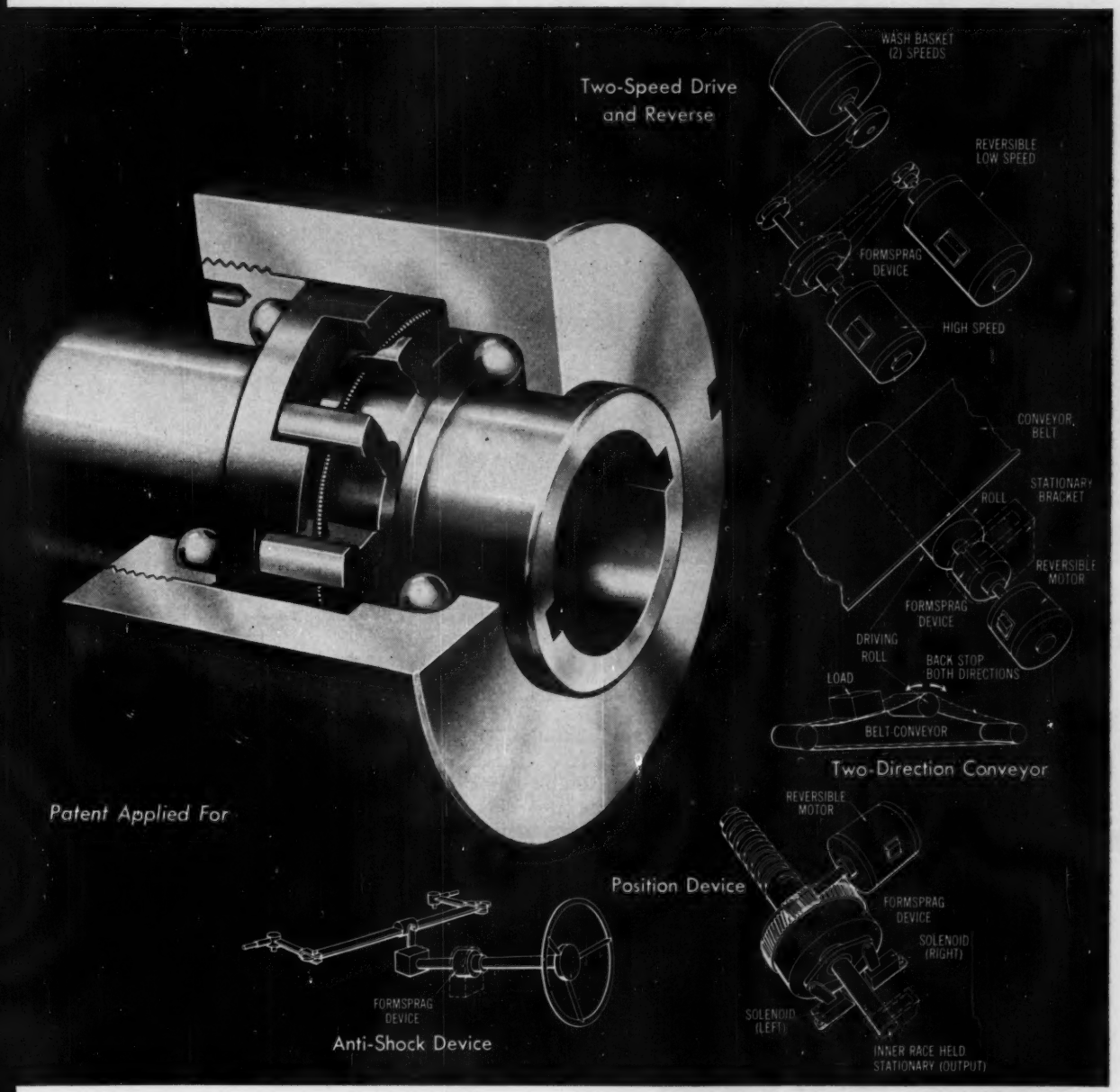
Here is a multi-purpose device, that not only drives, positions, over-runs and backstops in two directions, but also provides automatic, instantaneous and positive prevention of feedback from driven equipment to power source. It is compact, has greater torque capacity for its size and weight and permits higher over-running speeds than any similar device. Operation and features are explained in detail in a new Formsprag technical paper, send for your free copy.

FORMSPRAG COMPANY, 23603 Hoover Road, Dept. 105, Warren (Detroit), Michigan
Distributors in Principal Cities.

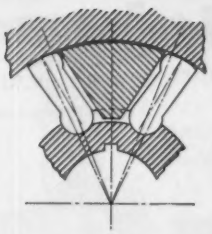


FORMSPRAG CLUTCHES

Precision Power Transmission Products



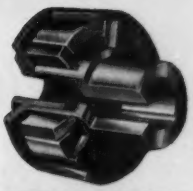
BECAUSE there is a complement of sprags arranged in opposing pairs, there is always a multiple number of contact surfaces engaging the outer race when feedback or backstopping conditions are present. This provides equalized radial loading and strong holding torque against even unusually heavy feedback.



The entire complement of sprags, which is a part of the output member assembly, rotates at driving speed while outer race remains stationary. Thus, sprags are in light contact with the outer race and are always in position to pick up the feedback load at constantly changing points on the outer race. This design feature assures longer life through even distribution of wear over entire surface of outer race. With sprags in constant contact with outer race, any independent movement of output shaft causes instantaneous locking of sprags—there is no backlash on output shaft.

RAWSON Centrifugal Clutches

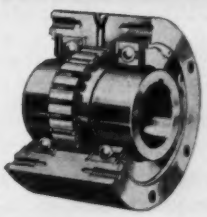
No-Load Motor Starts, Cushioned Starting of High-Inertia Loads, Overload Protection.

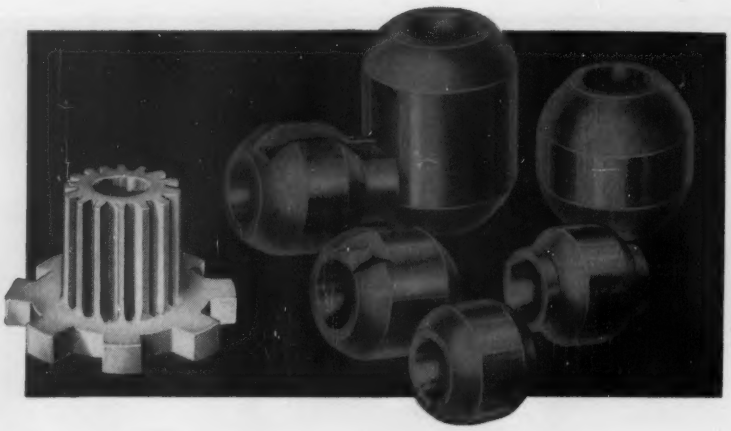


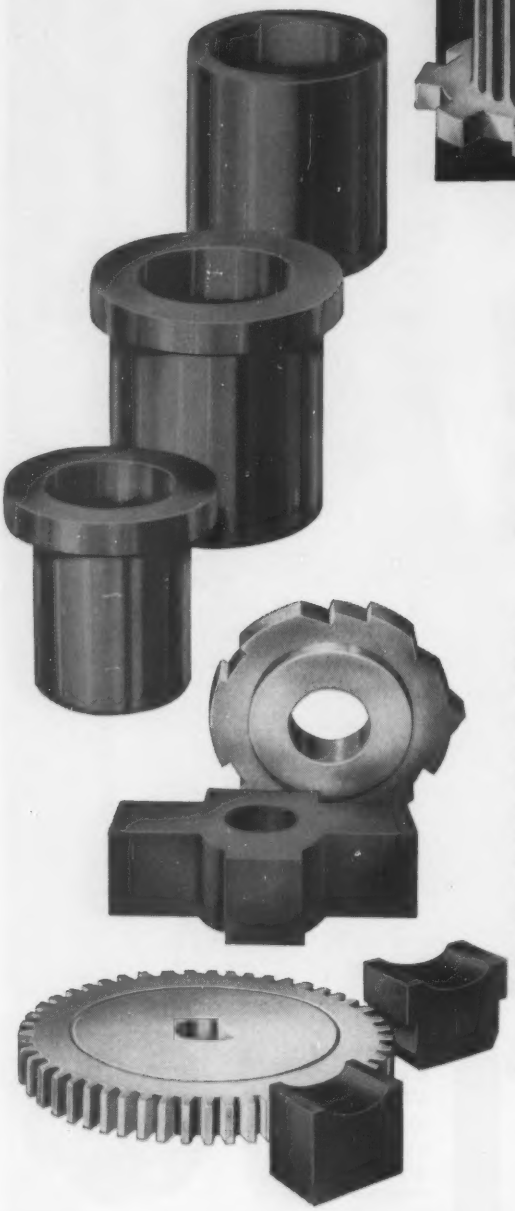
OTHER FORMSPRAG PRODUCTS

FORMSPRAG Over-Running Clutches

For Every Over-Running, Indexing & Backstopping Application







Johnson Powder Metallurgy

Bronze or Iron

Bearings . . . Bushings . . . Parts Offer Many Important Savings

Pre-Lubrication—The porous structure of Johnson powder metallurgy products acts as a reservoir for the lubricant, providing sufficient oil during operation . . . storing it when at rest. This feature often eliminates costly lubricating devices and systems, guards against neglect and assures longer operating life of the unit.

Formed to size—The manufacturing process is essentially a forming and sintering operation. This eliminates machining, prevents scrap, yet provides accuracy at a low unit cost. Uniformity of each bearing, or part, cuts assembly time to a minimum. These are but two of the many money-saving features of Johnson powder metallurgy bearings, bushings, and structural parts. Let us show you how to design your product to take full advantage of this economy yet gain greater performance and longer service life. No obligation of course. Write for literature today.

Johnson Bronze

525 South Mill Street • New Castle, Pa.

Subsidiary: Apex Bronze Co., Oakland, Cal.

JOHNSON Bearings

POWDER METALLURGY—BRONZE OR IRON

ALUMINUM ON STEEL SOLID ALUMINUM

BRONZE ON STEEL

STEEL AND BABBITT

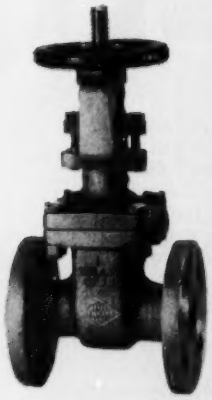
GRAPHITED BRONZE

BRONZE—CAST OR ROLLED

For 99 out of 100. . .

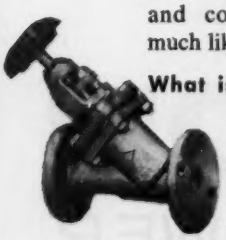
Selection of Stainless Steel Valves can be as simple as selection of Bronze and Iron valves

HOW to keep it simple? Don't let the wide selection of stainless steel alloys "throw you"!



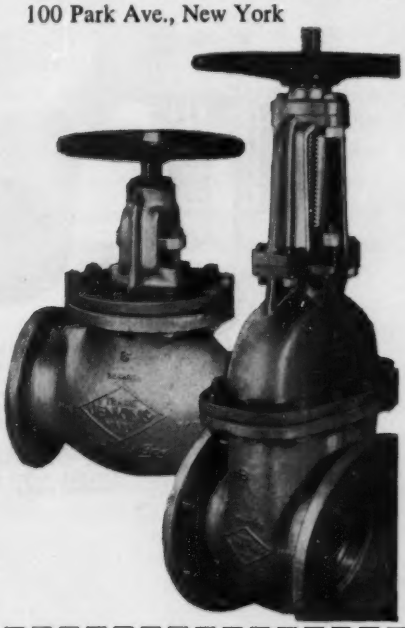
Most of the alloy specs were developed to meet certain highly specialized and rather uncommon needs. Only 1 out of 100 valve users can make practical use of many of the alloys. *Actually, just two or three of the different available alloys will give a big majority of valve users all they want and need.*

You can judge DESIGN differences between the various "makes" exactly as you do it with Bronze and Iron valves. Look them over and compare. Basically, of course, a Stainless Steel valve is designed and constructed very much like other valves.



What is left to worry about in addition to Material and Design? The same factors you consider in buying ANY valves for long, dependable performance: Are the valves made merely good enough, or to a standard that demands an extra-measure of quality? How good are the castings? How precise and perfect is the machining? How rigid is the inspection and testing during manufacture? These are the factors which specs can't cover. Some of them you can't see when you look at the valve. But you KNOW how to make sure they measure-up to peak standards. You know that the name JENKINS VALVES and the famous Jenkins DIAMOND trademark have been the highest assurance of quality for nearly a century.

Specify *"Jenkins"* as well as the metal alloy to assure fullest satisfaction. Your Jenkins Distributor has patterns and alloys to satisfy most industrial needs. Of course, they meet valve industry specifications and the high standards established by leading users of stainless steel valves. Jenkins Bros., 100 Park Ave., New York



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100 Park Ave., New York 17.
Send Jenkins Stainless Steel Valve Catalog to —

Name & Title.....

Company.....

Address.....

JENKINS VALVES

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DENISON HydrOILics

This AUTOMATIC® truck handles hefty steel coil like a baby with smoother, safer DENISON hydraulic power

FLUID POWER

HYDRAULIC HANDLING *for steel coil. This "Skylift Giant" unit was developed by Automatic Transportation Co., Chicago—Division of Yale & Towne Mfg. Co. The "Coil Up-Ending Attachment" is powered by Denison Axial Piston hydraulic pumps.*

FLUID POWER for this "Skylift Giant" industrial truck—equipped with a special "Coil Up-Ending Attachment"—means it can easily heft rolls of coiled steel weighing from 10 to 40 tons. *Denison hydraulic power pays off here in smoother, faster, safer handling.*

In leading mills, these heavy-duty trucks speed handling and storage without damaging coils. The Coil Up-Ending Attachment enters the coil's inside diameter with a fixed ram . . . while the outside is gripped by a powerful hydraulic clamp. This clamp-and-ram design prevents "telescoping" of coils during handling.

Three hydraulic cylinders—powered by motor-driven Denison 3,000 psi Axial Piston Pumps—furnish lifting and clamping power. All three cylinders are connected hydraulically in parallel, which results in a telescopic-cylinder action—but has the added advantage of retaining equal force and speed throughout the stroke at constant pressure and delivery.

Result: Operator easily controls lowering speed at any level . . . and can inch the load up from extremely slow speed to maximum for which the flow control is set. *Safe, fast, smooth hydraulic control helps keep "Skylift" trucks continuously on-the-job . . . handling extra payloads.*

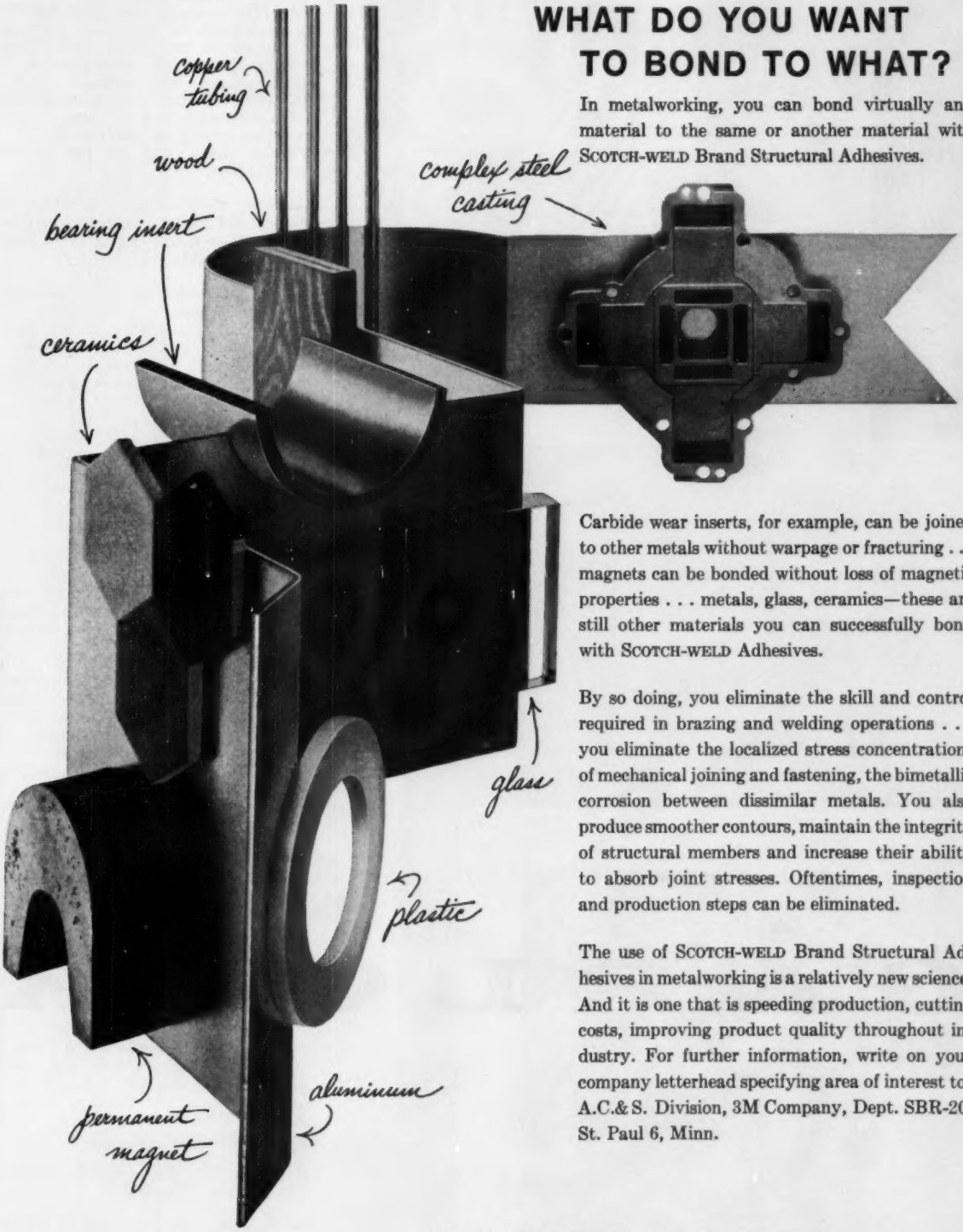
Here's the kind of job your Denison Hydraulic Specialist can help *you* do *now*. Call him in. See how Denison hydraulic power can help put *more payload into your equipment.*

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

HYDRAULIC PRESSES
PUMPS • MOTORS • CONTROLS

DENISON
HYDRAULIC POWER

Circle 446 on Page 19



WHAT DO YOU WANT TO BOND TO WHAT?

In metalworking, you can bond virtually any material to the same or another material with SCOTCH-WELD Brand Structural Adhesives.

Carbide wear inserts, for example, can be joined to other metals without warpage or fracturing . . . magnets can be bonded without loss of magnetic properties . . . metals, glass, ceramics—these are still other materials you can successfully bond with SCOTCH-WELD Adhesives.

By so doing, you eliminate the skill and control required in brazing and welding operations . . . you eliminate the localized stress concentrations of mechanical joining and fastening, the bimetallic corrosion between dissimilar metals. You also produce smoother contours, maintain the integrity of structural members and increase their ability to absorb joint stresses. Oftentimes, inspection and production steps can be eliminated.

The use of SCOTCH-WELD Brand Structural Adhesives in metalworking is a relatively new science. And it is one that is speeding production, cutting costs, improving product quality throughout industry. For further information, write on your company letterhead specifying area of interest to: A.C.&S. Division, 3M Company, Dept. SBR-20, St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

PLASTICS
in Design
Engineering

HOW TO SAVE TIME AND MONEY

Choose Garlock as *the* source for all your plastic needs. They've had years of experience in injection molding, compression molding, extruding, punching, machining, and grinding of stock shapes and intricate parts. "Know-how" like this enables Garlock to recommend and furnish plastic materials *exactly* as you need them . . . without delay and at the lowest possible cost.

Garlock offers a wide selection of shapes and parts—regardless of size, tolerance, or quantity—in these engineered materials:

Teflon† TFE—contains the finest combination of chemical, electrical, and mechanical properties . . . chemically inert, outstanding electrical qualities, low coefficient of friction . . . withstands temperatures as low as −395°F, as high as +500°F.

Nylon—guaranteed bubble-free . . . has high tensile and compressive strength, good resistance to heat and chemicals, solvents, oils and greases, retains toughness at temperatures ranging from −40°F to +350°F.

Polychlorotrifluoroethylene (C.T.F.E.)—colorless, non-flammable . . . offers excellent dielectric properties, high compressive strength, resistance to chemicals, low cold flow in temperatures from −400°F to +390°F.

Teflon FEP—combines the exceptional properties of Teflon with the advantage of being easily melt-processed . . . **Delrin†**—offers metal-like strength and rigidity over a wide temperature range . . . **Polyethylene**—light, flexible, excellent electrical properties . . . **Polypropylene**—lightest of all known materials.

Garlock will work directly to your specifications or, upon request, will gladly assist you in product design and development.

GARLOCK

For complete information contact one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada, or write for Plastics Catalog AD-171, The Garlock Packing Company, Palmyra, N. Y.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

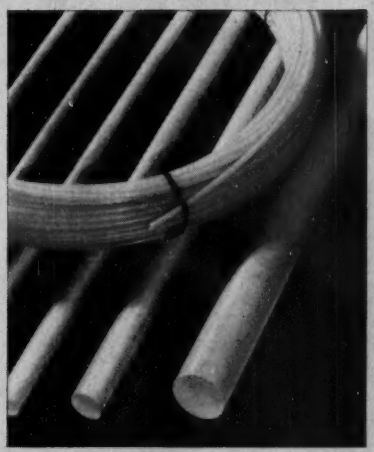
Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†DuPont Trademark

Circle 448 on Page 19

TEFLON (above), NYLON, C.T.F.E., DELRIN, other industrial plastics are available from Garlock for a wide range of electrical, mechanical and chemical applications.



WORLD'S LARGEST STOCK OF PLASTICS, such as this Nylon rod and tubing, is located in warehouses convenient to you . . . assures you prompt service any time, anywhere.

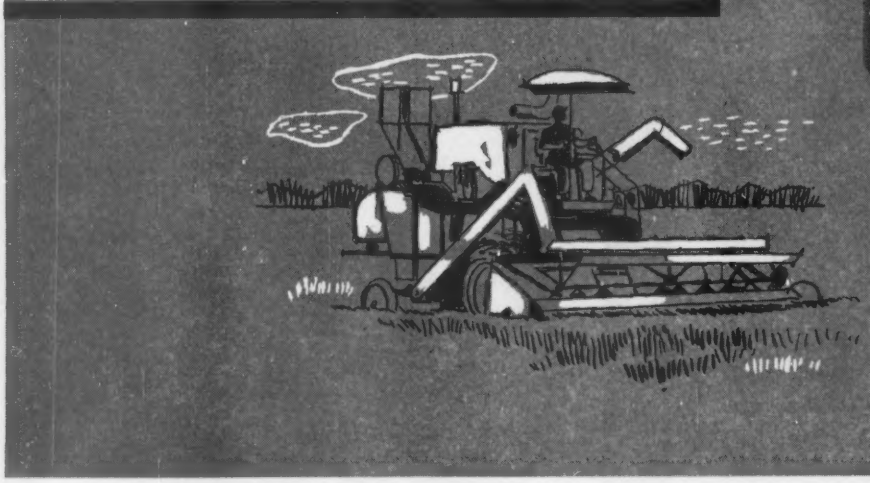
DIFFICULT MOLDED AND MACHINED PARTS, like these of Teflon and C.T.F.E., offer no problem to Garlock . . . intricate shapes, thin sections, close tolerances are routine.

two more cases where **PARTS PRODUCED FROM provide excellent bearing properties**

CASE HISTORY

MUELLER BRASS CO. 600 ALLOY screw machine product used in heavy duty farm equipment

This heavy duty planetary pinion shaft, made as a screw part from tough "600" series bearing alloy, was the answer to a continuing wear problem encountered in the driving mechanism of heavy-duty farm equipment and big trucks. The part is machine produced to exacting tolerances and all necessary finishing operations are done by Mueller Brass Co. so the pinion shaft is ready for installation when received. Since "600" alloy parts have been installed, no operating failures have been reported and the shafts have proved far superior to the material formerly used.



MUELLER BRASS CO. ANALYSIS SERVICE

You get sound, unbiased advice on the one best method of making your parts because Mueller Brass Co. is the only fabricator in the country offering all these methods of production. An experienced Methods Analysis Department has at its command a complete knowledge of the advantages and limitations of each production process. This unique technical service is your assurance of getting the best product at the best price . . . made the one best way!

COLD-PREST IMPACT EXTRUSIONS

PLASTIC INJECTION MOLDING

MUELLER BRASS CO.

MUELLER BRASS CO. 600 ALLOY

and maximum wear resistance in tough applications

CASE HISTORY

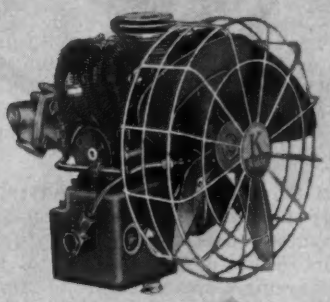
MUELLER BRASS CO. 600 ALLOY forgings used in aviation air compressors

Analyzing the job requirements of Walter Kidde & Company, Inc., for a main driving cam component to be installed in a reciprocating type of aircraft air compressor, Mueller Brass Co. Methods Analysis Engineers decided on a forging fabricated from "600" alloy as the most practical method of production. Since the cam forms the prime component of the driving mechanism, it must have good bearing wear surfaces and because the compressors are used in the aviation industry, the cams must be completely dependable. The close grained, strong forging that resists combination compressive and tensile stresses was the answer.

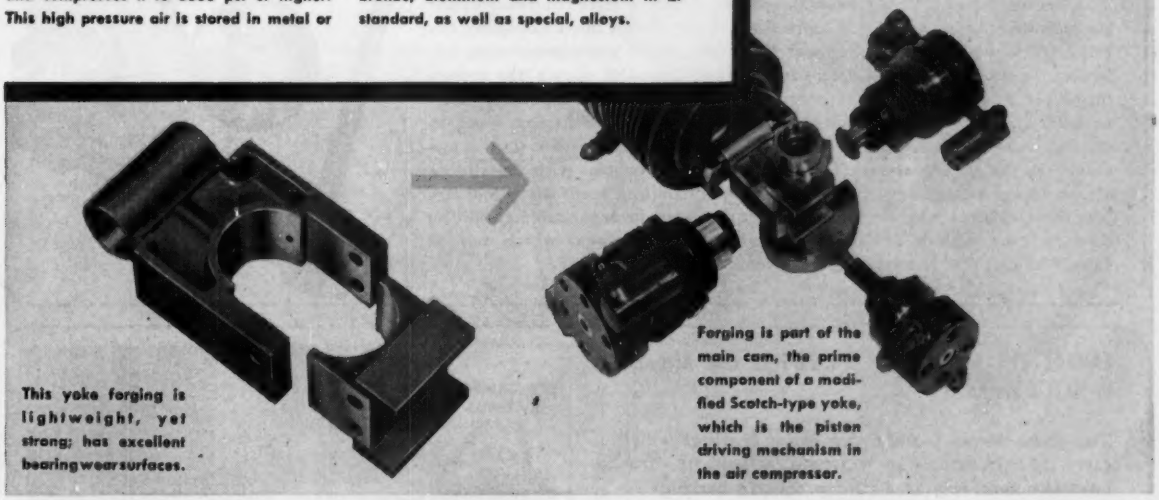
A typical compressor takes in ambient air and compresses it to 3000 psi or higher. This high pressure air is stored in metal or fiberglas containers until needed for actuation of pneumatic system components such as solenoid control valves, brake valves, manual control valves or actuators. These and other pneumatic units retract the entrance door, operate landing gear, wheel brakes, nose wheel steering systems, propeller brakes or perform other functions.

Aircraft in which Kidde compressors are installed include the Boeing 707, the Douglas DC-8, the Lockheed Electra, the Fairchild F-27 and various military aircraft.

Mueller Brass Co. produces press, hammer or cored forgings of any practical shape from a few ounces to 150 lbs. in brass, bronze, aluminum and magnesium in 27 standard, as well as special, alloys.



Aircraft air compressor equipped with hydraulic drive delivers air compressed to 3000 psi at the rate of 6 cfm.

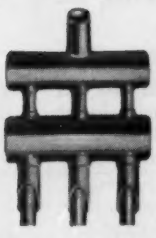


This yoke forging is lightweight, yet strong; has excellent bearing wear surfaces.

Forging is part of the main cam, the prime component of a modified Scotch-type yoke, which is the piston driving mechanism in the air compressor.

POWDERED METAL PARTS

SAND CASTINGS



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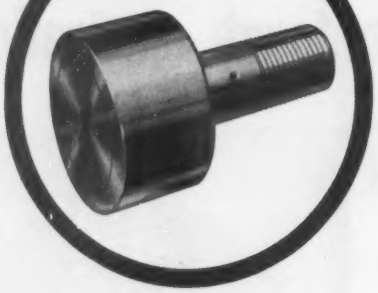
BEARING TIPS
by McGILL



CAMROL®
BEARINGS SIMPLIFY DESIGN and PRODUCTION

. . . add precision and reduce maintenance as cam followers, track and guide rollers

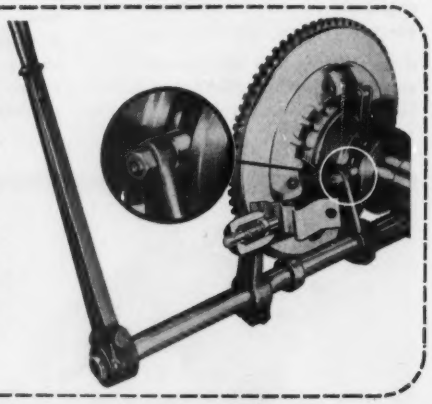
McGILL CAMROL CF Series and (sealed) SCF Series bearings offer definite design, production and maintenance advantages over "built-up" improvised bolt and roller units. Stock units with integral studs eliminate the procurement and assembly of components. They are built to high precision anti-friction bearing standards for assured machine accuracy. A full complement of rollers provide high load capacity in relatively small radial space. Specially heat treated studs provide the proper toughness to withstand shock loading. Integral seals in the SCF Series lock pre-lubrication in — contamination out.

In the CYR Series and (Sealed) SCYR Series CAMROL bearings the integral stud is replaced by an inner ring for yoke or shaft mounting.

Available in roller diameters from ½" to 4"; capacities to 20,480 lbs. at 100 RPM.

Sealed Camrol Bearings Cut Maintenance in Twin Disc Power Take-offs

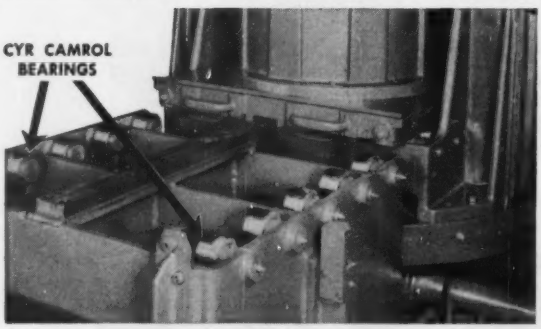
To meet the demand for a power take-off which can operate continuously for six months without additional lubrication, Twin Disc Clutch Company has produced a modified line of Power Take-Offs which use CAMROL cam followers. In the new Limited Attendance Power Take-Off, shown, the bronze throw-out collar used in the standard units is replaced with a positive clearance mechanism in the 10-inch and larger sizes. This mechanism employs CAMROL sealed cam followers which ride in an annular groove that is machined in the sliding sleeve. The followers are in contact with the sliding sleeve during engagement and disengagement handling loads up to 800 lbs. The integral seals keep the pre-lubricated bearings in dependable condition through long periods of time and prevent premature wear which may be caused by dirt and grit entering unsealed bearings.



CAMROL CYR Bearings are Trouble-Free and Accurate in NATCO Machines

The photo shows CAMROL CYR Series bearings which carry jig-type fixtures in NATIONAL AUTOMATIC TOOL COMPANY multi-spindle machines. 24 CYR bearings reduce friction and provide smooth, trouble-free, and accurate operation in these machines.

NATIONAL AUTOMATIC TOOL COMPANY reports that they have "never had a service report as to the malfunction of a MCGILL bearing."



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precision needle roller bearings

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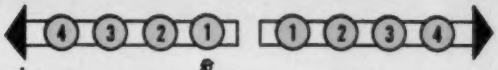
McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

Circle 450 on Page 19

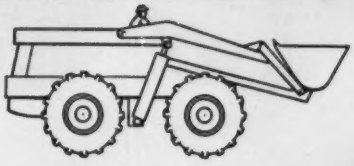
only the HYDRA-DRIVES® BDB

OFFERS ALL THESE MAJOR ADVANTAGES

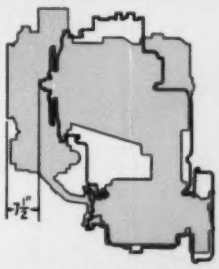
IN FULL-POWER SHIFT TRANSMISSIONS for equipment from 60 to 175 h.p.

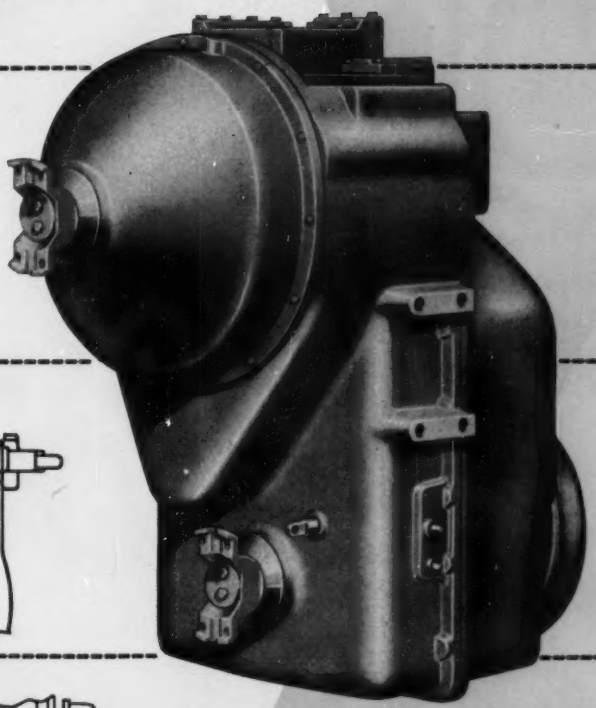


1. **4 speeds forward and reverse.** All power shifted! Provides maximum horsepower to load under all load conditions.

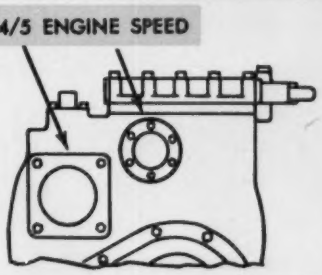


2. **Integral design.** Torque converter, transmission, oil passages, valving and oil sump are in *one* compact housing—7½" shorter than comparable models.

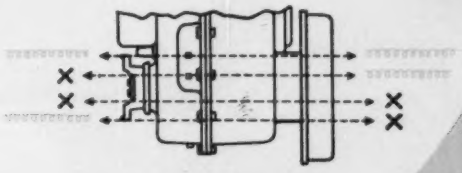




3. **Dual reduced speed pump drives.** Pumps can be driven at engine speed or ⅘ engine speed for longer life and increased horsepower to pump load. Single pump drive is also available.



4. **Full disconnect** provides four combinations of split drive . . . from torque on both shafts, to both shafts in disconnect.



SPECIALLY DESIGNED FOR SMALLER INSTALLATIONS

Rockwell-Standard's new model Hydra-Drives Full Power Shift Transmission is now available in sizes especially designed for smaller installations, such as front end loaders, fork trucks, scrapers, crane carriers, rubber tire tractors and military vehicles.

In addition, the Hydra-Drives BDB offers easier servicing and maintenance. There are fewer moving parts and bearings. The simple, rugged countershaft design and spur gears simplify maintenance.

HYDRA DRIVES
ROCKWELL-STANDARD CORPORATION
TRANSMISSION AND AXLE DIVISION
DETROIT 32, MICHIGAN

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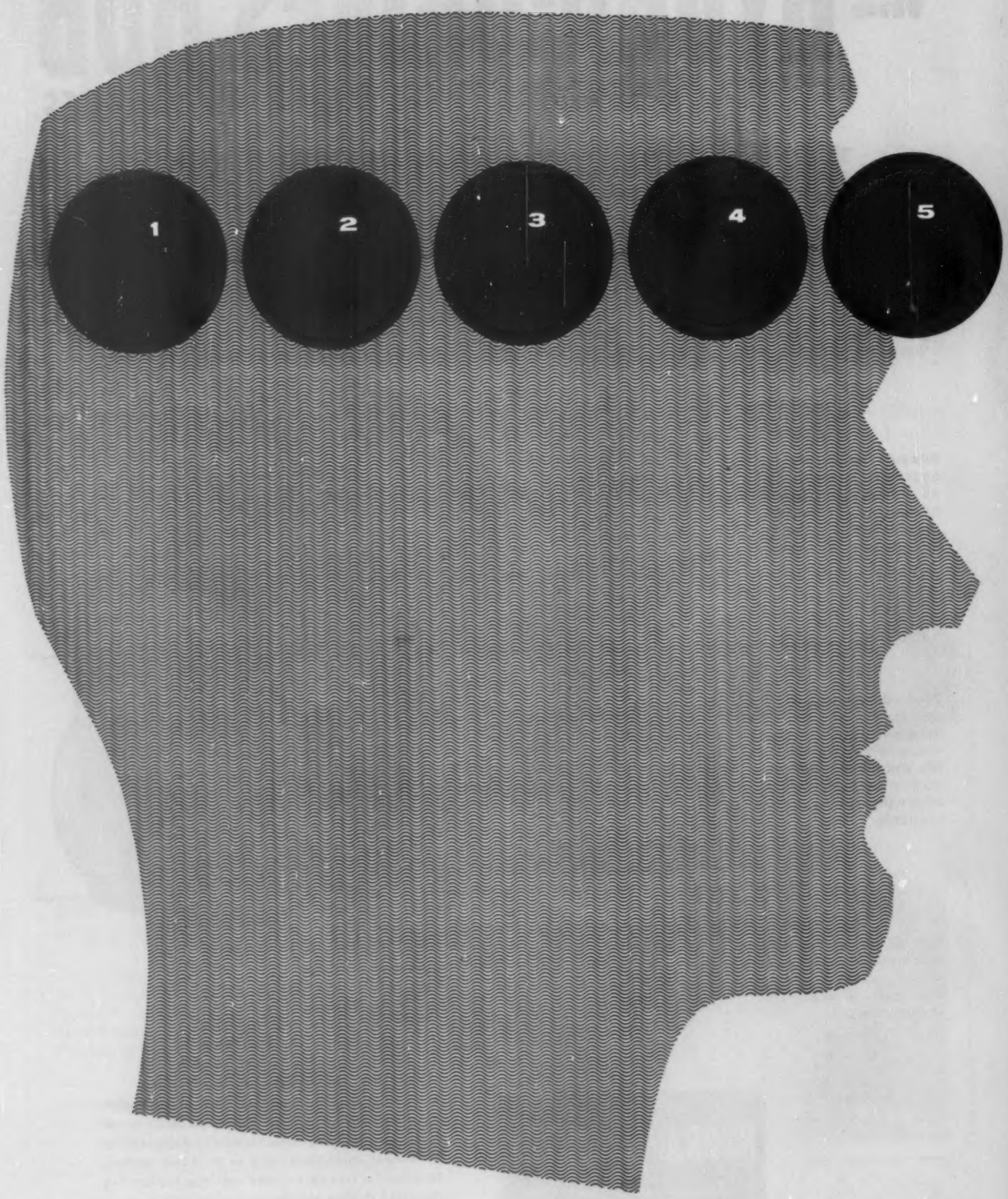
1
2
3
4
5

count to ten . . .

and then

scream

That shipment of high temperature alloys hits your receiving dock. Everything goes great. No production headaches. No kicks from the field. Your wife looks several years younger and the dog doesn't growl at you any more.

You reorder from the same company. Still no problems . . . except you can't stop smiling while you shave. All told, you get nine separate shipments from this source. You're beginning to think high temperature alloy problems are the fantasies of fools.

So you place order number ten. Same supplier. Same grade. Same everything . . . except *this* lot fails to get by the eagle eye of your inspector. You've got a real procurement problem. Schedules suffer. Now your wife looks twenty years older and the dog snaps at your heels and you would trade your favorite putter for a high temperature alloy you can count on.

Carpenter hasn't come up with a cure for all your woes, but we have perfected a revolutionary new steelmaking process which minimizes variations from lot to lot. Called the MEL-TROL® process, it features a patented mold which reduces segregation of harmful impurities during solidification of the ingot. Result: you get clean, sound, tough metal from surface to centerline . . . in every bar . . . every time you order.

Now predictable performance is yours for the asking.

tool and die steels
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***Carpenter* steel**

a new company 70 years old

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Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

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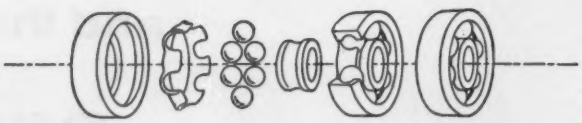


MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON,** *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

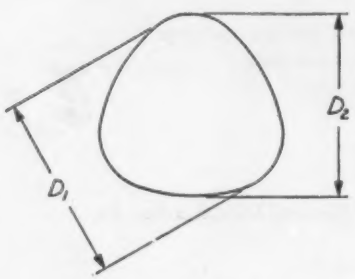
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

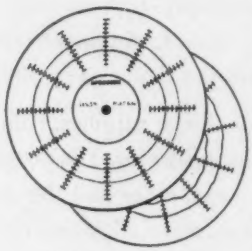
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

NEW HAMPSHIRE BALL BEARINGS, INC.
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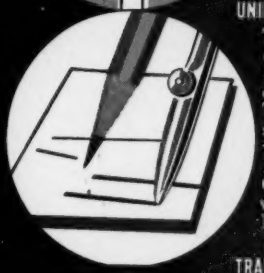

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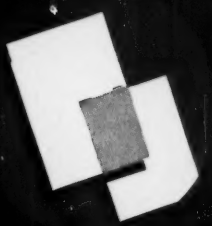

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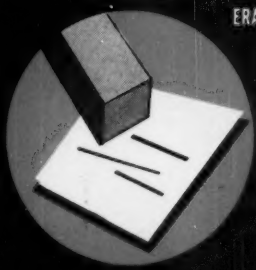

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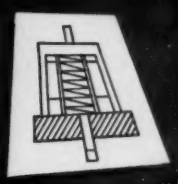

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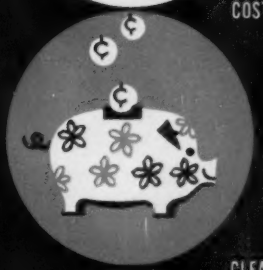

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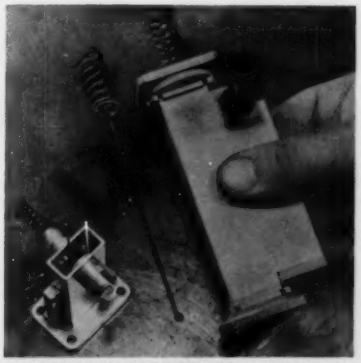
NS SPECIAL WIRE KEEPS SPRINGS ALIVE IN 1400° BATH

When a leading manufacturer of microwave assemblies and radar components was faced with a serious production bottleneck in a high-temperature dip-brazing operation, they came to National-Standard for help in solving the problem.

CRITICAL MICROWAVE ASSEMBLIES being brazed in a 1400° salt bath were held together by cumbersome weights and intricate fixtures that frequently caused distortion or slippage during the brazing operation. The solution—and a considerable time and money saver—was to clamp all the components with springs that would allow expansion of the various parts during brazing without distorting the assembly. However, conventional spring wire would not retain tension at 1400°. Once used, springs had to be discarded.

NATIONAL-STANDARD ENGINEERS, working with the manufacturer's engineers, tested a new superalloy spring wire, NS-25 (L605), that proved "as good as new" after several hundred brazing operations at 1400° F. The mechanical stability of NS-25 spring wire insures proper expansion of parts during heating and maintains just the right tension to give mating parts good contact and perfect bond. The result is manufacturing that is simplified, faster and more precise than was previously possible.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.



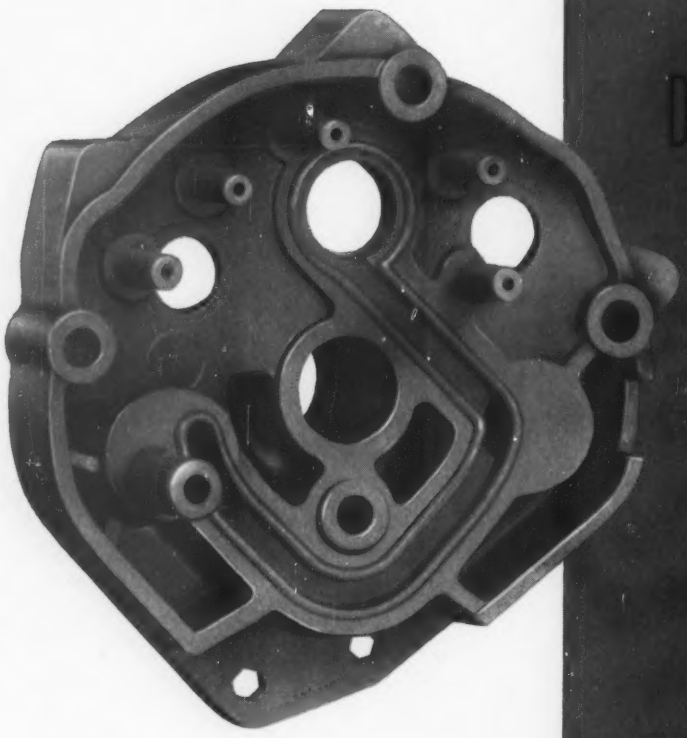
MICROWAVE ASSEMBLIES are held together in 1400° brazing bath by springs made of NS-25 wire. This special alloy wire allows rapid, precise brazing never before possible.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan



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This is a prime example of maximum utilization of the die casting process.

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ISSUE NO. 17

the neg'ator® sketchbook

The NEG'ATOR® Spring is a new basic mechanical component—a coiled band spring which extends many times its original size without the increasing force common to conventional springs. Used as an extension spring, a motor, band, clamp, or clip, this revolutionary new constant-force component upsets all previous spring principles by doing what springs have never done before.

CONCEALED NEG'ATOR® SPRING CLAMPS COVER, ALLOWS 4 IN. MOVEMENT

The photo, Fig. 1, shows a section of an I-T-E Circuit Breaker protruding from the switchgear cubicle, withdrawn to the "test position." A gap between a cut-out section of the compartment door and the protruding assembly is filled by a dust plate which fits around the escutcheon plate and seats against the inner face of the door. When the door is opened, the cut-out clears the escutcheon plate, leaving the dust cover at rest against the plate.

The problem—how to maintain contact between the inner surface of the door and the dust plate.

(*continued on reverse of this page*)

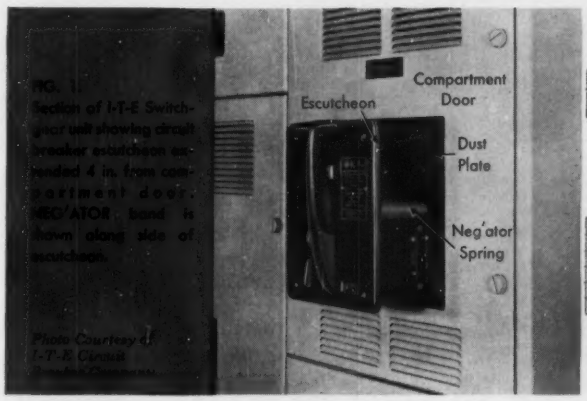

FIG. 1. Section of I-T-E Switchgear unit showing circuit breaker escutcheon extended 4 in. from compartment door. NEG'ATOR® band is shown along side of escutcheon.

Photo Courtesy of I-T-E Circuit

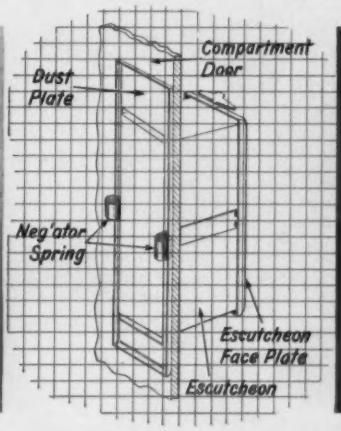

FIG. 2. Drawing shows how NEG'ATOR springs hold dust plate against inner side of compartment door. The coiled end rests against inner side of dust plate. Extended ends are riveted to the back of the escutcheon face plate.

TINY SPRING COIL PROVIDES 14 IN. CARRIAGE RETURN

Many modern mechanisms involve repeated linear travel. When driving force is unidirectional, the design engineer must, in some cases, provide a reacting force to overcome driving force and return the traveling device to its initial position.

In such applications, engineers have found "no gradient" NEG'ATOR springs offer unusual advantages, especially in cases where constant force, long travel, and space saving are important.

Such a case is shown in Fig. 3. This Intrafax Facsimile Transmitter, designed by The Western Union Telegraph Company, uses a constant-force NEG'ATOR spring to provide an unvarying carriage return force.

As the scanning carriage travels 14 in. from its initial position (at right of the drum in Fig. 4) to the farthest point of motion (where it is located in photo) the spring band is unravelled from a spool on which it is coiled. The tendency of the NEG'ATOR spring to return to its natural coiled condition on the spool produces the same reacting force at all carriage positions. When the carriage drive is stopped, the free carriage is returned to its initial position as the spring recoils onto the spool.

Tests indicated that an extension spring of practical size could not provide satisfactory force throughout the range of travel. Only a NEG'ATOR spring could.

The NEG'ATOR used is made from a .004 in. x ¾ in. x 20 in. strip of spring steel. The spool, 1 3/16 in. long and ¾ in. in diameter, is mounted on the transmitter frame. The outer end of the spring is secured to the scanning carriage. In specifying the NEG'ATOR spring, optimum force was selected for positive return action without excessive acceleration.

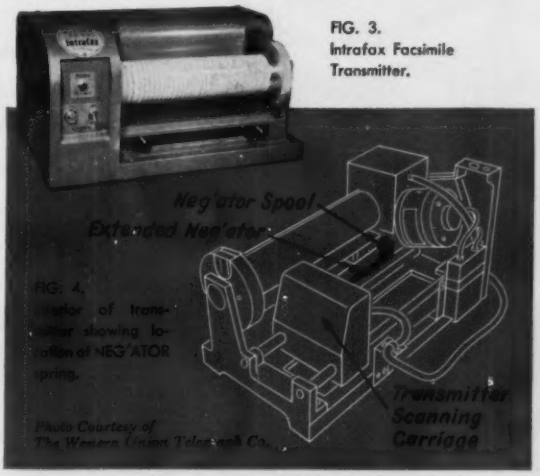

FIG. 3. Intrafax Facsimile Transmitter.

FIG. 4. Interior of transmitter showing location of NEG'ATOR spring.

Photo Courtesy of The Western Union Telegraph Co.

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(continued from reverse of this page)

CONCEALED NEG'ATOR SPRING...

Fixed linkages wouldn't work. One unit had to move independently of the other. Coiled extension or compression springs were impractical since they could not be mounted in the available space.

The solution—a self-coiling, constant-force NEG'ATOR spring made of type 301 stainless steel, 6 in. long, .005 in. thick, and 1 in. wide.

As shown in Fig. 2, two of these flat springs hold the dust plate against the back side of the door in three breaker positions and still allow the escutcheon plate to move free of the door. The coiled end of the NEG'ATOR spring rolls up against the inner side of the dust plate. The extended flat end is riveted to the back of the escutcheon's face plate.

In all three positions, the coiled end of the spring exerts a constant force of 2 lbs. against the inner side of the dust plate and holds it against the inner surface of the door to maintain a tight seal. In addition, the wide, flat spring tends to hold the dust plate straight, allowing smaller top and bottom balance notches. Thus, NEG'ATOR springs provided an ideal method for solving a design problem involving limited space and low but adequate force.

INGENIOUS ENGINEERS USE NEG'ATOR SPRING TO SAVE $38 IN COST OF MACHINE

Engineers at Acme Steel Company have discovered still another application for the NEG'ATOR spring. Using it as an adjustable-length strapping guide they replaced a slotted steel bar and saved about $38 in the cost of every Acme FIE semi-automatic strapping machine.

In earlier machine models, a solid, slotted steel bar formed the floor of a trough in the top plate assembly and acted as a strapping guide. As shown in Fig. 5, the bar was grooved to accept protruding fingers of an adjustable back stop which acts as a ramp to guide straps upwards.

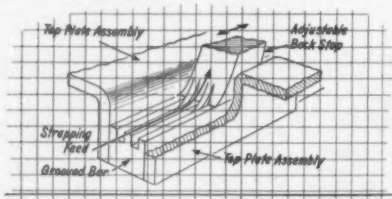


FIG. 5. Old models of strapping machine used solid, grooved bars to guide straps.

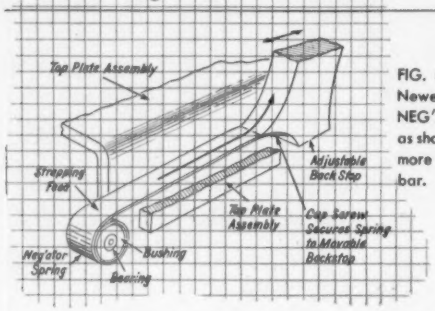


FIG. 6. Newer models use NEG'ATOR spring as shown to replace more costly steel bar.

In newer models, the NEG'ATOR spring replaces the steel bar. See Fig. 6. When extended to any length up to 9 in., depending upon the package size, the straightened portion of the NEG'ATOR provides a flat surface to guide the strapping beneath the package to the curved back stop. The back stop guides the strapping upwards behind the package where it can be grasped by the operator.

The encircling operation is completed when the operator carries the strap over the package and inserts it in a slot in the table of the machine. The strap is then tensioned, cut, and welded.

The spring is made of type 301 stainless steel .010 in. thick and .750 in. wide.

While not used as a spring in this application, the tension developed by the NEG'ATOR spring gives it the stiffness required to guide the strapping through the open trough.

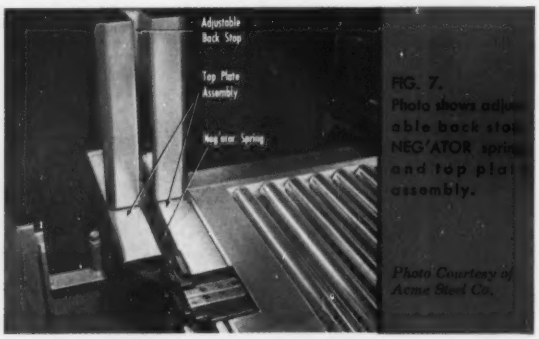


FIG. 7. Photo shows adjustable back stop, NEG'ATOR spring and top plate assembly.

Photo Courtesy of Acme Steel Co.

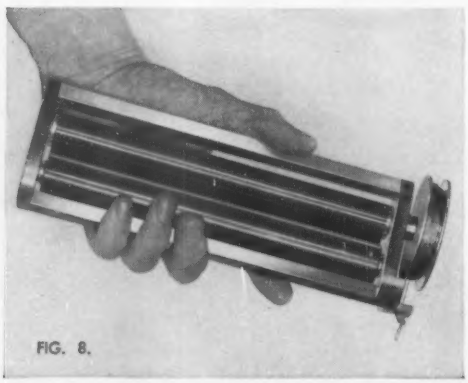


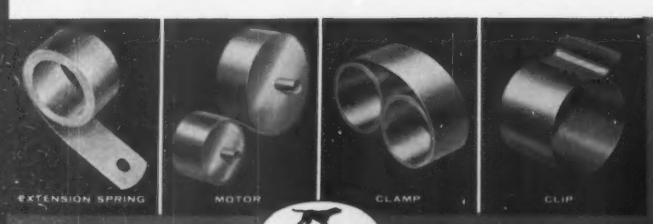
FIG. 8.

HELP US NAME THIS NEW NEG'ATOR MOTOR

The NEG'ATOR Motor shown in Fig. 8 has been described as the "slimline" motor. While this name expresses one particular characteristic of this design, it doesn't quite do it justice and we're pretty sure it's somebody else's term. Can you think of a better word or combination of words to describe it? Here are some details—

The NEG'ATOR spring used is stainless steel, .0033 in. thick x 7¾ in. wide. The spring is mounted on two bushings, one ½ in. in diameter, the other ¾ in. in diameter. The motor will provide 50 turns and produces a constant torque of 6 lb.-in. nominal. An idea of size and its long, nearly tubular shape can be determined from the photo. It is ideal for providing powerful mechanical drive in long, thin cavities—can be used in combinations, as a counterbalance, retriever, and in many other ways.

We want a good generic name, not a trademark. What word—derived from its shape, power, or uses—would best convey to an engineer what this motor can do for him? Hunter will give an 8 mm Movie Camera—the latest model with a NEG'ATOR motor drive to the person submitting the most apt name or combination we can use to describe this motor. Offer ends March 31, 1960.



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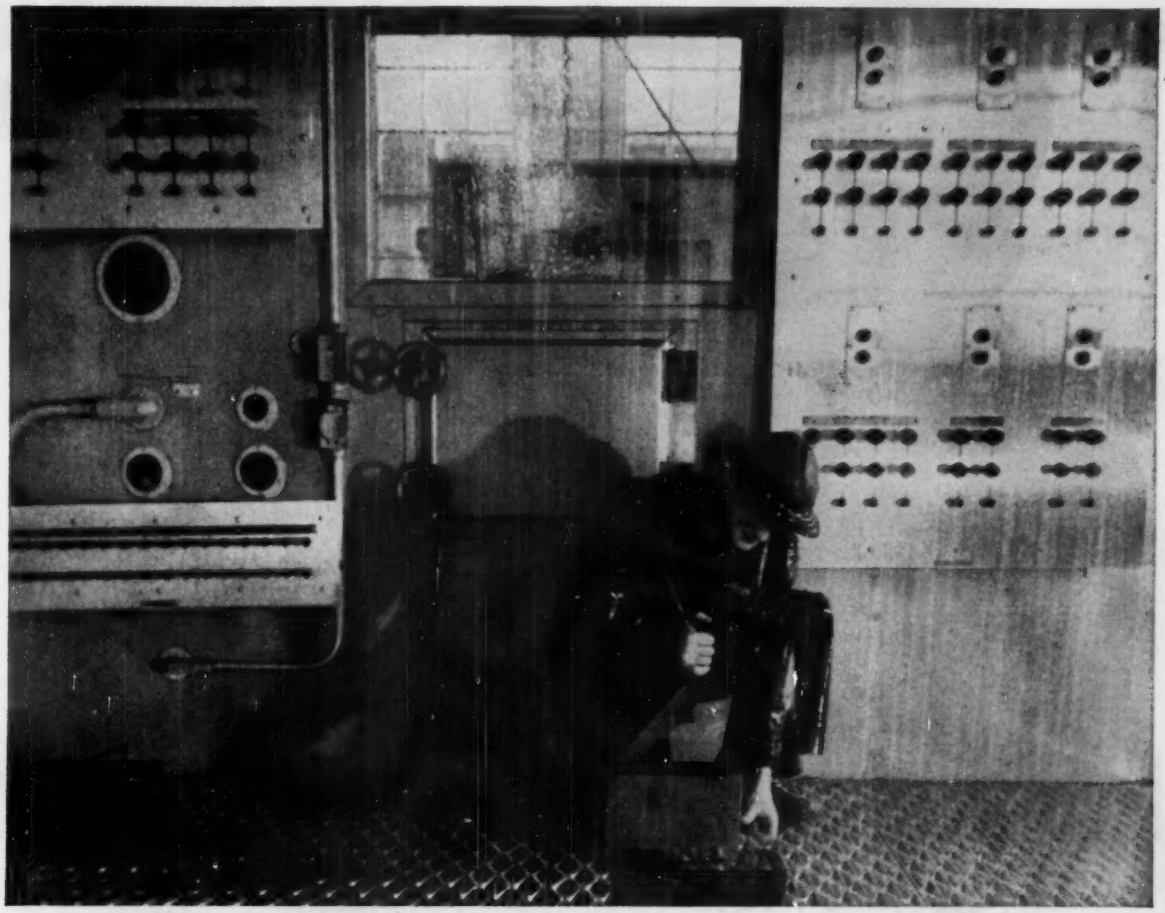


In test chambers of the U. S. Army...

Nickel meets the torture of man-made weather

Sometimes it's as steaming as the Malayan jungle...sometimes as hot as the Sahara...and then an arctic storm blows in. Nowhere in the world does Nature brew up such changeable weather as men do in Philadelphia.

Here in weather chambers of the U.S. Army, military equipment undergoes weather conditions that make Mother Nature seem like a gentle old soul by comparison.

If you think this is tough on the equipment, how about the chambers themselves. The equipment is in and out, but the chamber has to take it for test after test. That's why the designers line them with a Nickel Stainless Steel—Type 18-8. Nickel Stainless Steel *can* take it. It's corrosion resisting in the wettest atmosphere. It withstands sub-zero temperatures. The shocks of see-sawing "weather" conditions harm it not at all.

Still another Nickel alloy—a nickel-chromium type — lines heat test units where temperatures get up over 1200°F. Another nickel-chromium alloy is used for the glowing heating elements.

Make your own forecast of what a metal must face—Nickel and its alloys can help you meet the challenge. Is it ability to meet stress, fatigue, heat or cold, corrosive atmospheres or a combination of these? We may be able to help you find the answer in Nickel. Just write.

Weather chambers like this one designed by Tenney Engineering, Inc., Union, N. J., are lined with Nickel Stainless Steel. Notable installations include those at the U. S. Army's Frankford Arsenal, and Sperry Gyroscope Company, Long Island, N. Y.

The International Nickel Company, Inc. INCO **67 Wall Street · New York 5, N. Y.**

INCO NICKEL

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

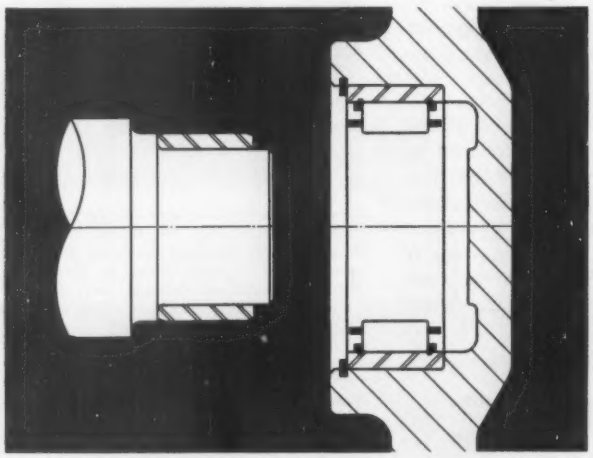
ALL THESE SOLVED WHEN

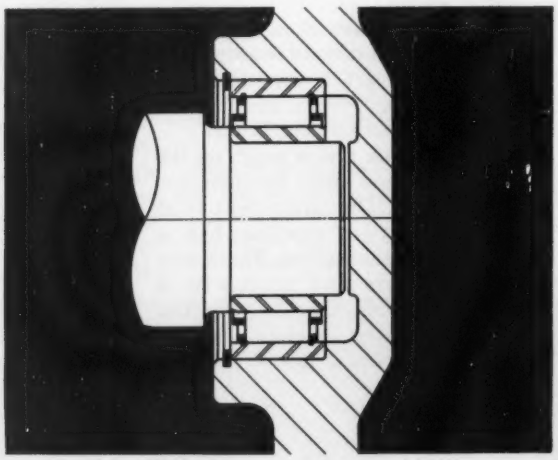
SAVE COST

Again, how simple this shaft becomes when you use Hyatt Hy-Roll bearings. It's easy to design, quickly drawn and requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be pressed on the shaft . . . to become, for your purposes, virtually a part of the shaft. Since Hyatt Hy-Roll races are made from case-hardened, carburizing type steel, rather than through-hardened, they permit much heavier press fits without danger of cracking.

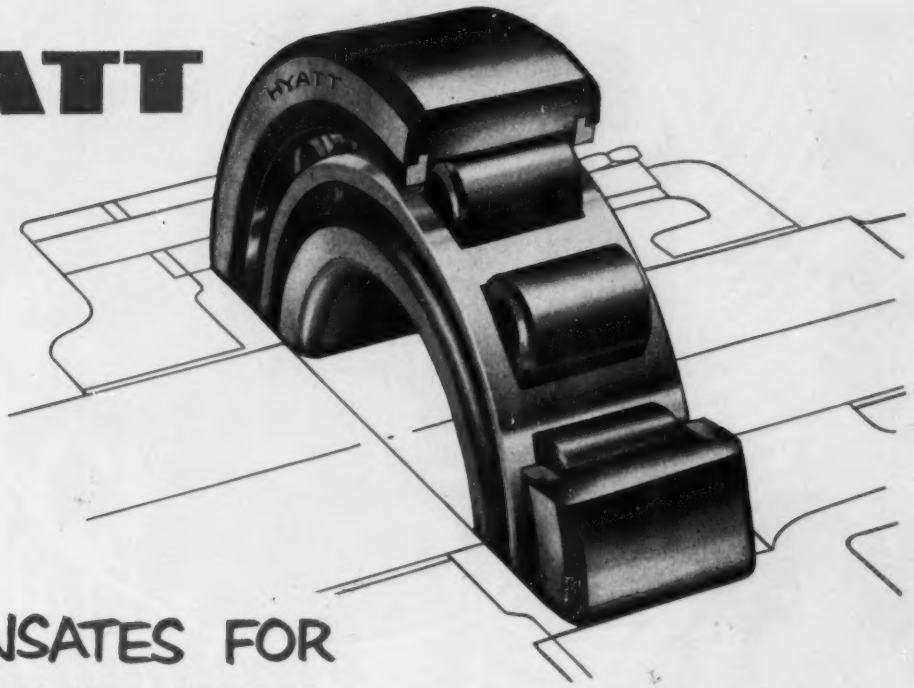
SAVE TIME

When equipment is being assembled you can see why Hyatt makes all separable races interchangeable within the same part number. It allows you to press an inner race on the shaft at one work station, then later fit it into any of the mating assemblies already installed in the housing. You don't have to worry about matched assemblies because with Hyatt Hy-Rolls selective fits are unnecessary. Think of the time it saves!





PROBLEMS ARE EASILY YOUR "SPECS" READ HYATT



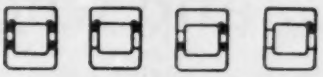
COMPENSATES FOR SHAFT EXPANSION

Heat can be a critical factor in the choice of a radial bearing. When the temperature rise causes lateral shaft expansion, it's safer to avoid laterally locked bearings. Used on a long shaft, they become misaligned, cramped, and overloaded when the shaft begins to heat up and expands laterally.

It's a problem you can avoid, very simply, with Hyatt Cylindrical Roller Bearings. In Hyatt's design, an extra length, separable inner race allows the shaft to float horizontally. This bearing compensates for lateral expansion, automatically, without changing the bearing centers and without depending upon uncertain float of a bearing loosely fitted in a housing. The usual practice is to hold one end of the shaft or roll while you allow "free lateral" at the other end by using a Hyatt Hy-Roll Bearing with a separable inner race.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable



—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

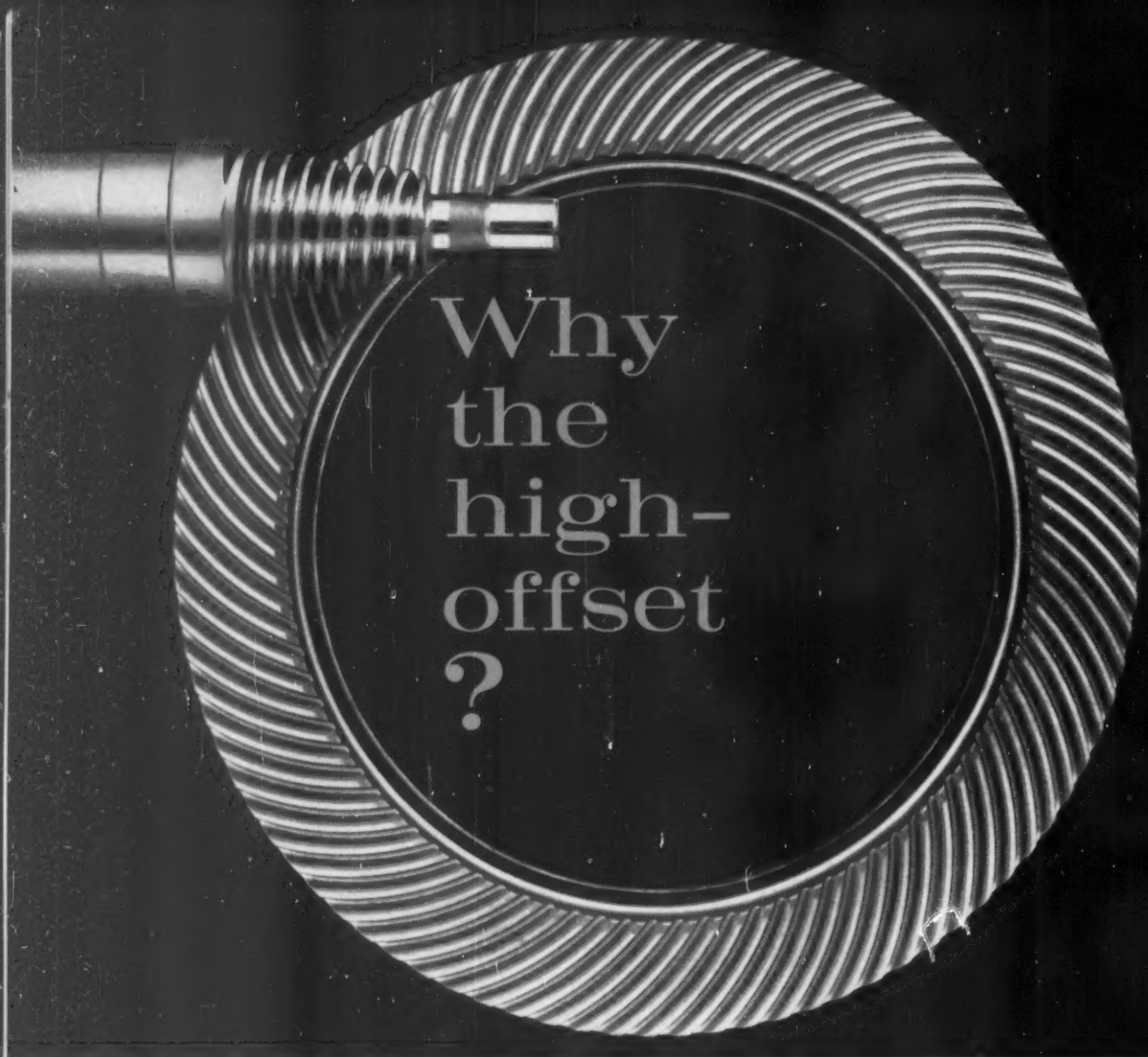
For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM RELIABILITY

Circle 458 on Page 19



...and where can you use it profitably?

High-offset makes a difference!

It's the difference that lets you combine *high-reduction* with strength, compactness and other advantages you might find profitable in certain applications. For instance . . .

For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because the teeth "wrap around" the pinion, *you get continuous action—even with just one or two teeth.*

Where space is a problem—as in instrumentation—the high-offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.

Where you need strength—as in farm machinery—high-offset hypoid pinions with teeth, which tend to "wrap around," are larger and stronger than corresponding bevel pinions.

High-offset or high-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish. For ratios of 1:10 or 1:40 or even higher.

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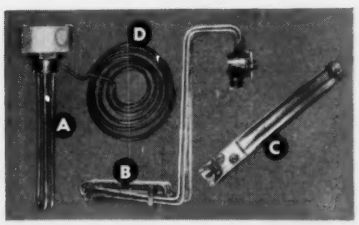
Liquid Heating Guide

How to choose electric heaters for liquid heating applications

Here is condensed information to help you get the most economical electric heaters for your liquid heating design problem.

Three factors generally determine which type heater should be used for any particular liquid-heating application. They are: the physical characteristics of the container, the nature of the liquid, and the temperature requirements.



General Electric "screw-in" immersion heaters (a) have threaded headers, which make for easy and permanent installation in pipes, tanks and vessels. "Over-the-side" immersion heaters (b) hang in tanks or containers, and besides being portable, they are ideally suited for heating rubber-lined tanks, lead-lined tanks, tanks of wood, slate, and other materials which are not adaptable to heaters with threaded headers.

Because some metals are subject to attack when immersed in certain liquids, G-E heaters are made in a variety of sheath materials so that they can be used for a wide range of liquids. Sheath materials of copper, steel, stainless steel, nickel, nickel-plated copper, nickel-silver, Inconel, Monel, cast iron and lead are all available.

General Electric heaters are ideally suited for heating a wide range of liquids: water, oil, electroplating baths, cleaning compounds, chemical baths, and other fluids. These liquids can be circulating or non-circulating; in open containers, closed or pressure; vessels; kettles, or steam generators. Heavy viscous liquids, such as pitch, molasses, and asphalt can be heated by using a liquid jacket containing immersion heaters.

Where extremely corrosive liquids are to be heated, it is also often best to use a water jacket around the tank. Immersion heaters may be used for water heating in this type of application. Many times, it is easier to clamp strip heaters (c) or tubular heaters (d) to the side of the tank.

TABLE I—Water, Alkaline or Plating Baths

Amount of Liquid		Degrees F Temperature Rise						
Cubic Feet	Gallons	20	40	60	80	100	120	140
		Kilowatts to Heat in One Hour						
.66	5	0.3	0.5	0.8	1.2	1.6	2	2.7
1.3	10	0.5	1.1	1.6	2.4	3.2	4	5.3
2.0	13	0.8	1.6	2.4	3.6	4.5	5.7	7.2
2.7	20	1.1	2.2	3.2	4.8	6	7.5	9.5
3.3	25	1.3	2.7	4	6	7.5	9.5	12
4.0	30	1.6	3.2	4.8	7	8.8	11	14
4.7	35	1.9	3.7	5.6	8	10	13	16
5.3	40	2	4	6	9	12	15	20
6.0	45	2.4	5	7	11	14	18	23
6.7	50	2.7	5.4	8	12	15	19	24
7.4	55	3	6	9	13	16	20	25
8.0	60	3.3	6.4	9.6	14.5	18	23	29
8.7	65	3.5	7	10	15.5	19.5	25	31
9.4	70	3.7	7.5	11	17	21	26	33
10	75	4	8	12	18	23	29	37
10.7	80	4.3	8.5	13	19	24	30	38
11.4	85	4.5	9	13.5	20	25	31	39
12.0	90	5	10	14.5	22	28	35	44
12.7	95	5	10	15	23	29	37	47
13.4	100	5.5	11	16	24	30	38	48
16.7	125	7	13	20	30	38	48	60
20.0	150	8	16	24	36	45	57	72
23.4	175	9	18	28	42	53	67	85
26.7	200	11	21	32	48	60	75	95
33.7	250	13	27	40	60	75	95	120
40	300	16	32	47	70	88	110	140
46.8	350	19	37	56	83	105	130	165
53.4	400	21	43	64	96	120	150	190
60.1	450	24	48	72	107	135	170	214
66.8	500	27	53	80	120	150	190	240
Maximum Time (hours)		10	10	7	5½	5	4	3½

TABLE II—Use This Table for Oil

Amount of Oil To Be Heated		Degrees F Temperature Rise					
Cubic Feet	Gallons	50	100	200	300	400	500
		Kilowatts to Heat in One Hour					
.5	3.7	.3	.5	1	2	2	3
1	7.4	.5	1	2	3	4	6
2	14.9	1	2	4	6	8	11
3	22.2	2	3	6	9	12	16
4	29.9	2	4	8	12	16	22
5	37.4	2	4	9	15	20	26
10	74.8	5	9	18	29	40	52
15	112.5	7	14	28	44	60	77
20	149.6	9	18	37	58	80	102
25	187.	11	22	46	72	100	127
30	222.5	13	27	56	86	120	151
35	262.	16	31	65	100	139	176
40	299.	18	36	74	115	158	201
45	336.5	20	40	84	129	178	226
50	374.	22	45	93	144	197	252
55	412.	25	49	102	158	217	276
60	449.	27	54	112	172	236	302
65	486.	29	58	121	186	255	326
70	524.	32	62	130	200	275	350
75	562.	34	67	140	215	294	375
Maximum Time (hours)		10	10	8	7	6	5

To figure the amount of heat required for your application:

1. Find the number of gallons or cubic feet of liquid to be heated.

2. Figure needed temperature rise in degrees F. (Subtract initial temperature from needed temperature.)

3. Check either Table I or Table II from the nearest amount of liquid to the desired "temperature rise" in the right-hand column.

4. Add 4% to the figure you now have if there is no insulation on your container or tank.

5. Divide the answer in Step 4 by the number of hours available for initial heat-up of the liquid. You now know how many kilowatts of heat are required for your installation.

For complete information on sizes and ratings of General Electric heaters, call your General Electric Apparatus Sales Office or send coupon below.

DELIVERY TODAY: Popular sizes of General Electric heaters are available today from General Electric stocks near your plant.

SPECIAL SAMPLES: Your General Electric sales engineer can advise you on special heating problems. If special heaters are required, he will provide samples.

PROMPT SHIPMENT: General Electric's new Industrial Heating plant at Shelbyville, Indiana, is now geared to give excellent shipping dates on heaters for your production needs. Just call your nearest General Electric Apparatus Sales Office and tell us your requirements. General Electric Company, Schenectady 5, New York.

Section H723-26, General Electric Co., Schenectady 5, New York

Please send GEA-6305, heating water and baths; GEA-6306, heating oil and GEC-1005, catalog of G-E Heaters and Devices.

NAME.....

COMPANY.....

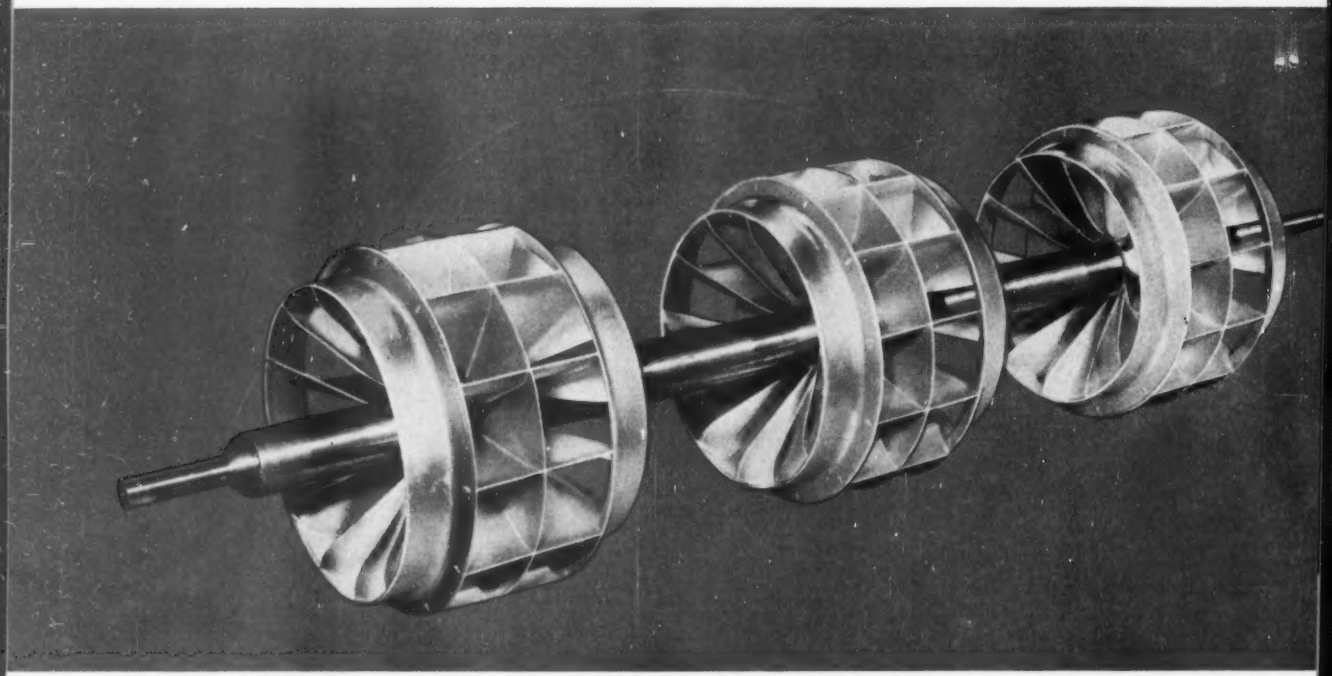
ADDRESS.....

CITY..... **STATE**.....

GENERAL ELECTRIC

Circle 460 on Page 19

TRULY CONCENTRIC ELECTRUNITE MECHANICAL TUBING ELIMINATES ROTOR SHAFT MACHINING



SCROLL-TYPE BLOWERS up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Careful balance and uniformity of the tubing is required for high operating efficiency.

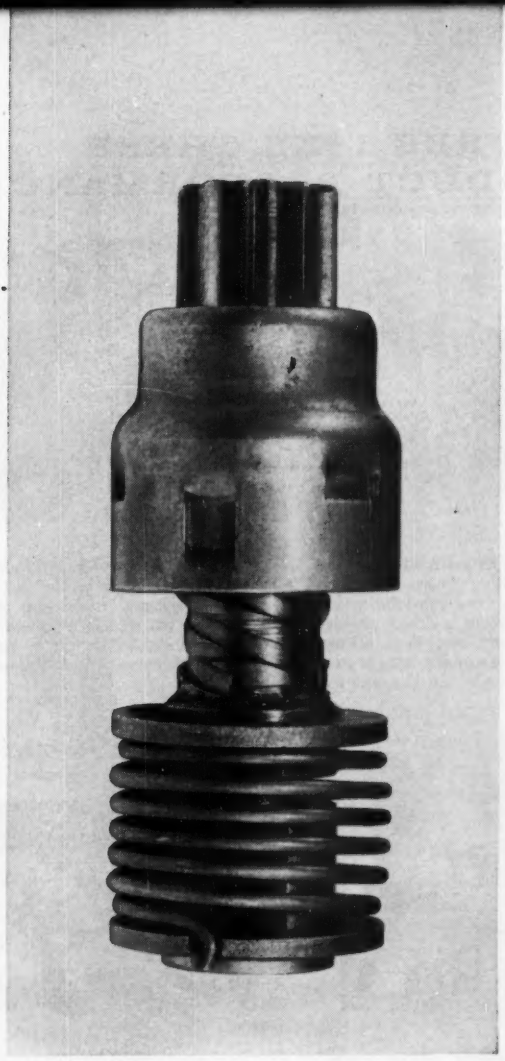
DUE TO THE UNIFORM CONCENTRICITY of Republic ELECTRUNITE Mechanical Tubing, no machining is required in producing air conditioning rotor shafts at Buffalo Forge Company. Rotor shafts are bored at each end and plug inserted for the bearing. Because of the uniformity of ELECTRUNITE, only .015 of the stock is removed before the plug is pressed into the tubing ends.

Buffalo Forge Company, Buffalo, New York, saves valuable machining time by using Republic ELECTRUNITE® Mechanical Tubing in manufacturing air conditioning and ventilating units. ELECTRUNITE in sizes of 3″ to 3¼″ O.D., 8-gage, is used as shafting for the rotors of the blower system.

Scroll-type blowers up to 27″ in diameter are mounted on ELECTRUNITE shafts, some up to 94″ long, and designed to operate at approximately 1,110 rpm. Small shafting will turn at 2,300 rpm. True concentricity of ELECTRUNITE is vital to high operating efficiency of these units due to the careful balance required in relation to the high rpm and weight involved.

Republic ELECTRUNITE Tubing, carbon or stainless, may solve your particular production or cost problems, too. Call your Republic representative, or write direct.

Circle 461 on Page 19



2.

3.

1.

1. **FIVE REPUBLIC METAL POWDERS** give you broad spectrum coverage. Republic's wide range of iron and alloy powders cover all known physical property requirements of metal part fabricators. Send for booklet, ADV. 1014 for complete technical information on Types G, N, S, and Type MS. Information on Type HS6460 is contained in booklet, ADV. 1028. Write today.

Circle 462 on Page 19

2. **REPUBLIC COLD DRAWN ALLOY STEEL** is used by a leading manufacturer for one of the most critical components in their automobile starter drive assemblies—the drive pinion. Use of Republic Cold Drawn Alloy provides the necessary strength and toughness to withstand severe torque, impact, and prolonged wear. Write for additional information.

Circle 463 on Page 19

3. **REPUBLIC NYLOK® FASTENERS** provide secure holding power where it's needed most in the Twin Power Riding Mowers produced by Roberton Manufacturing Company, Chicago. A special nylon insert assures positive locking, maximum holding power—even under severe vibration. The insert in NYLON fasteners is unaffected by age or cold, has high resistance to heat. Send coupon for additional data.

Circle 464 on Page 19

REPUBLIC STEEL

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-8736
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Please send additional information on the following products:

- ☐ Republic ELECTRUNITE Tubing ☐ Carbon ☐ Stainless
- ☐ Republic NYLOK Fasteners
- ☐ Alloy Steels
- ☐ ADV. Booklet 1014
- ☐ ADV. Booklet 1028

Name_____ Title_____

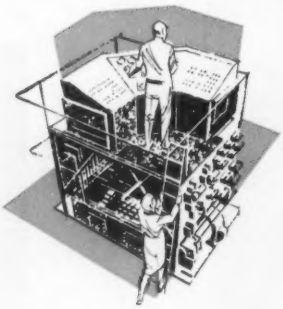
Company_____

Address_____

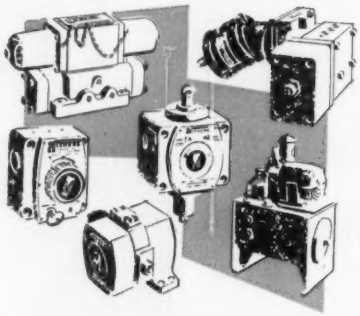
City_____ Zone____ State_____

BONUS FEATURES LIKE THESE BOOST YOUR PRODUCT PERFORMANCE

Advanced Design—More than 800 engineers and technicians plus unequalled research and development facilities devoted to every phase of hydraulics assure that Vickers will continue to provide the finest in products and systems.

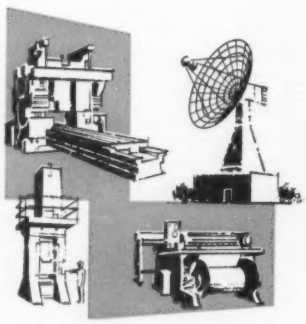


Unified Systems Responsibility—When the job calls for a more complex installation, you don't have to develop your own system by "shopping around". Vickers provides custom engineered, ready-to-go systems that invariably save you money in the long run.

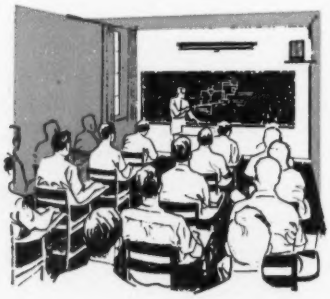


Most Complete Line—Because Vickers designs and builds the broadest line of top quality hydraulic components available anywhere you are assured of getting just what your installation requires. You don't have to compromise performance in any way.

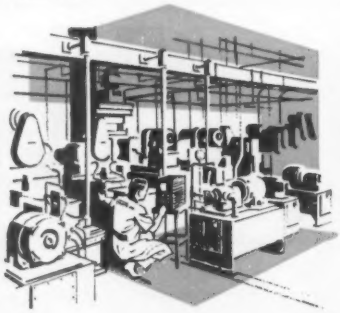
"Single Line" Application Engineering—You can rely on top quality field assistance in planning any hydraulic installation because your Vickers sales engineer is just that—a highly qualified engineer with responsibility for a single manufacturer's product line.



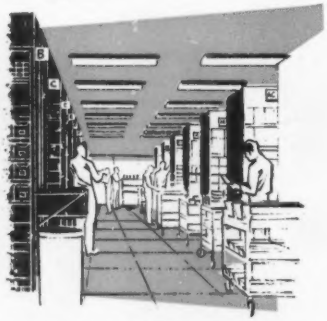
Hydraulic Experience without Equal—Nearly 40 years of experience in developing and building hydraulic equipment that has won a worldwide reputation for being advanced in design and reliable in performance stands behind every Vickers unit or system.



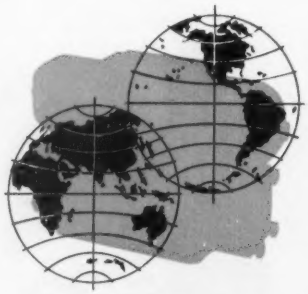
Customer Training—Your engineers, technicians and maintenance men benefit from attendance at Vickers' hydraulic school or Vickers-sponsored hydraulic conferences. These activities plus technical publications help keep industry posted on the newest fluid power ideas.



Unmatched Field Service—No matter where your equipment goes to work a skilled Vickers service man is close at hand to insure that it always performs as specified. Because he's responsible for a single manufacturer's product line, he's up-to-date on latest designs and techniques.



Regional Repair and Parts Stocking—Not only do Vickers units outperform and outlast ordinary designs but you have less downtime for maintenance too. When service is needed, regional service centers provide units tested to factory specifications assuring peak operating efficiency.



International Manufacturing Sales and Service—No matter where Vickers parts are made throughout the free world, they are completely interchangeable. Thus, you gain added freedom in design and manufacture of your product, particularly if it is intended for export sale.

Machine builders and users choose VICKERS® hydraulic pumps and valves by wide margin

"Machinery Magazine" study shows Vickers leads next brand by 4.4 to 1 in pumps, 6.4 to 1 in valves

Once again users and builders of machinery have shown an overwhelming preference for the quality and performance of Vickers hydraulic pumps and valves. In the recently completed "Machinery Magazine Brand Preference Study" Vickers pumps and valves not only attained considerably higher weighted scores than the runners up but enjoyed even wider margins in the "first choice" categories (see tabulation below).

Close cooperation with its customers—large and small—has characterized Vickers operations over the years and is reflected in this "vote of confidence" from the field. The end result is that buyers of machinery have come to accept Vickers-equipped machines as offering something extra in reliability and productivity.

When you specify Vickers hydraulic components, you get the finest hydraulic equipment of the most advanced design and more besides. Some of these extras are described briefly on the facing page. For more details on any of these or the complete line of hydraulic components or systems contact your nearby Vickers application engineer or write for the new Vickers catalog 5001.

HYDRAULIC PUMPS

	First Choice	Second Choice	Third Choice	Weighted Total %
Vickers	186	56	14	49.2
Company B	31	29	5	11.2
Company C	25	23	12	9.6
Company D	20	26	11	8.9

22 other companies accounted for the remaining 21.1% of the weighted total.

HYDRAULIC VALVES

	First Choice	Second Choice	Third Choice	Weighted Total %
Vickers	147	32	7	47.1
Company B	18	9	9	7.4
Company C	13	16	—	6.5
Company D	8	14	5	5.2

24 other companies accounted for the remaining 33.8% of the weighted total.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan 8496

Application Engineering Offices: ATLANTA • CHICAGO • CINCINNATI • CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON INDIANAPOLIS • LOS ANGELES AREA (El Segundo) • MILWAUKEE • NEW YORK AREA (Springfield, N.J.) • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lebanon) • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • WORCESTER
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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 466 on Page 19

We tailor our sheets to fit the application

Whether you need a steel sheet for deep-drawing, or one with a special surface requirement, you can count on Bethlehem to furnish just the right steel sheet for your needs.

Our modern mills at Sparrows Point, Md. and Lackawanna, N. Y. are as finely equipped and expertly manned as any in the nation. And our metallurgists will work with you all the way. We'd like the chance to serve you.

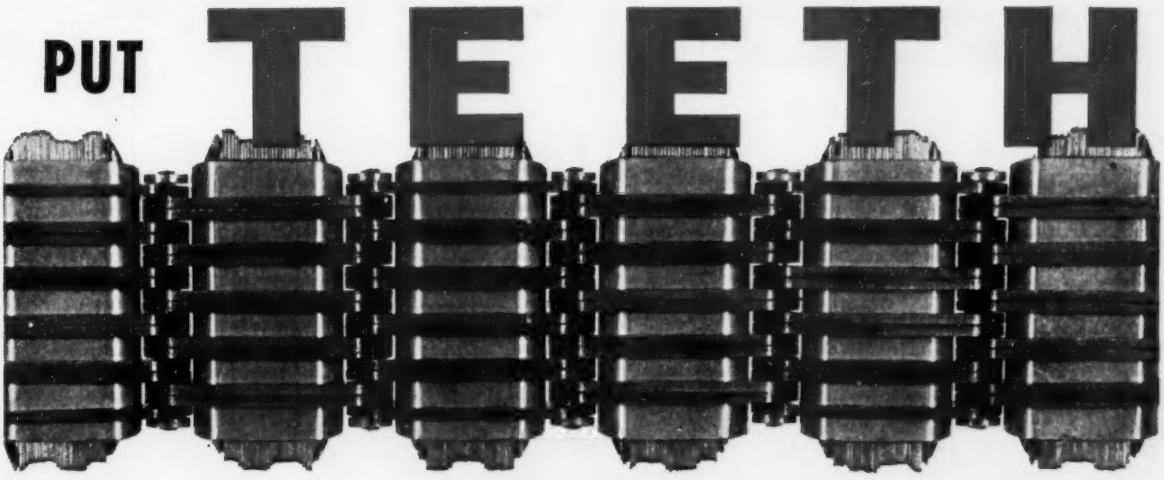
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

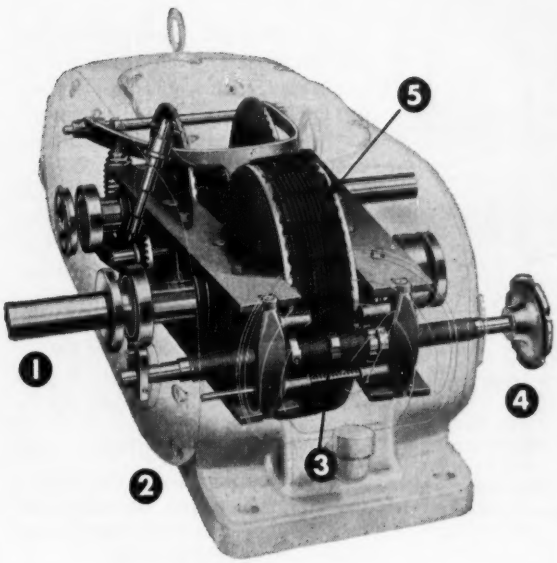
BETHLEHEM STEEL

BETHLEHEM STEEL

PUT TEETH



IN YOUR SPEED CHANGING JOBS



Get the positive, accurate control that only LINK-BELT's chain-driven P.I.V. can deliver

Yes, you put teeth into your speed changing jobs because Link-Belt P.I.V.—unlike other variable speed drives—utilizes an exclusive metal, self-tooth-forming chain.

Here's how it works! P.I.V. chain consists of a series of overlapping steel links. The links contain packs of slats which are free to move from side to side, singly or collectively, to serve as teeth. The chain meshes with radially grooved wheels, which are cut to a constant depth towards the wheel periphery. Beveled sides of the grooves offer gripping areas . . . provide a positive, nonslip contact at any speed, under all loads.

Makes changing speed simple too! A turn of the control screw simultaneously varies the effective diameters of the conically shaped wheels—closing one set, spreading the other. At the same time, the self-tooth-forming chain automatically adjusts to provide desired ratio between the input and output shafts.

BOOK 2274—Your Link-Belt office has Book 2274 on P.I.V. drives from ½ to 25 hp. Refer to the yellow pages of your local phone directory under Power Transmission Equipment.

(1) You can get minute speed changes and maintain them accurately while operating under full load.

(2) All-metal, totally enclosed—unaffected by atmospheric conditions. All vital operating parts splash-lubricated from a common housing reservoir.

(3) Easy-view speed indicator facilitates speed selection and adjustments to meet all requirements.

(4) An infinite number of positive, stepless speed adjustments may be made with manual, electric, pneumatic or hydraulic controls.

(5) Self-tooth-forming chain is made from a series of overlapping steel links. Links contain packs of hardened steel laminations or slats (shown above). Slats grip toothed wheels positively without slippage —give the speed you need at any setting.

15.242

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.

P.I.V. LINK-BELT
VARIABLE SPEED DRIVE

Gasket engineering

SEALING ALUMINUM FLANGES

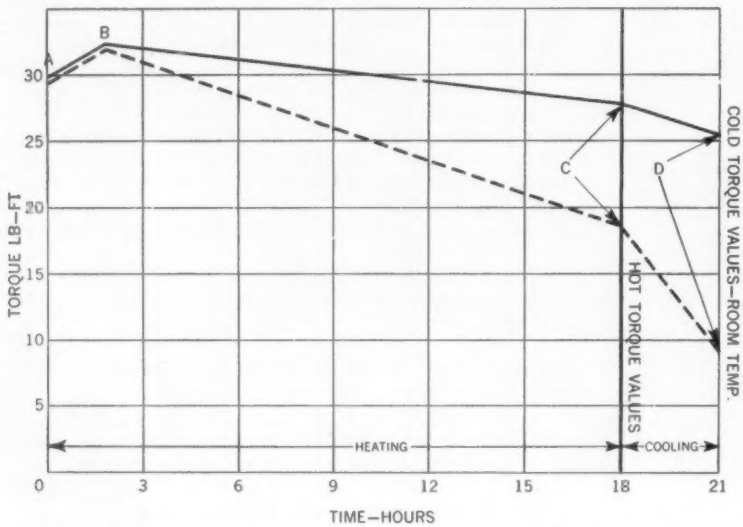
As heat expands aluminum flanges, gaskets often crush and extrude and bolt loading is reduced. New engineering research points way to better seals on these flanges.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

Where aluminum flanges are used . . . and particularly where they are exposed to alternate cycles of heat and cold . . . crushing and extrusion of gaskets and serious loss of bolt torque are often encountered.

creasing the unit load on the gasket. The consequent crushing and extruding of the conventional fiber gaskets led to substantial loss of bolt torque.

The study also turned up other data unique to aluminum flanges. This is the difference between "hot" torque readings—taken while the transmission is at 300° F. and "cold" readings, taken after the assembly cools. With iron or steel flanges, there is no significant difference between these readings. With aluminum, however, the difference often is 20% or more.



This diagram shows effect on torque retention of thermal cycling to 300° F. of gasketed joint with one aluminum flange and one cast iron flange. Torque increase from A to B results from aluminum expansion; B to C represents normal torque loss at constant oven temperature; C to D is loss resulting from aluminum contraction. Solid line is average result of tests with Accopac AN-890, which retains about 90% of the original bolt torque. The dotted line represents average test results with conventional gaskets, which retain only about one-third the initial torque loads after cycling.

To study this problem, Armstrong engineers set up simulated service tests with stock automotive transmission housings. These housings all have large aluminum members that are subject to wide variations in temperature, and all require high flange pressures.

The initial result of the tests indicated—as expected—that the expansion of the aluminum had the effect of in-

The difference between "hot" and "cold" torque readings is a measure of the ability of a gasket to "follow" the flange as it undergoes dimensional change. Ideally, a gasket should show no difference between hot and cold torque readings. It should resist crushing under high pressures and high temperatures—and it should compensate for the contraction of the flange as it cools.

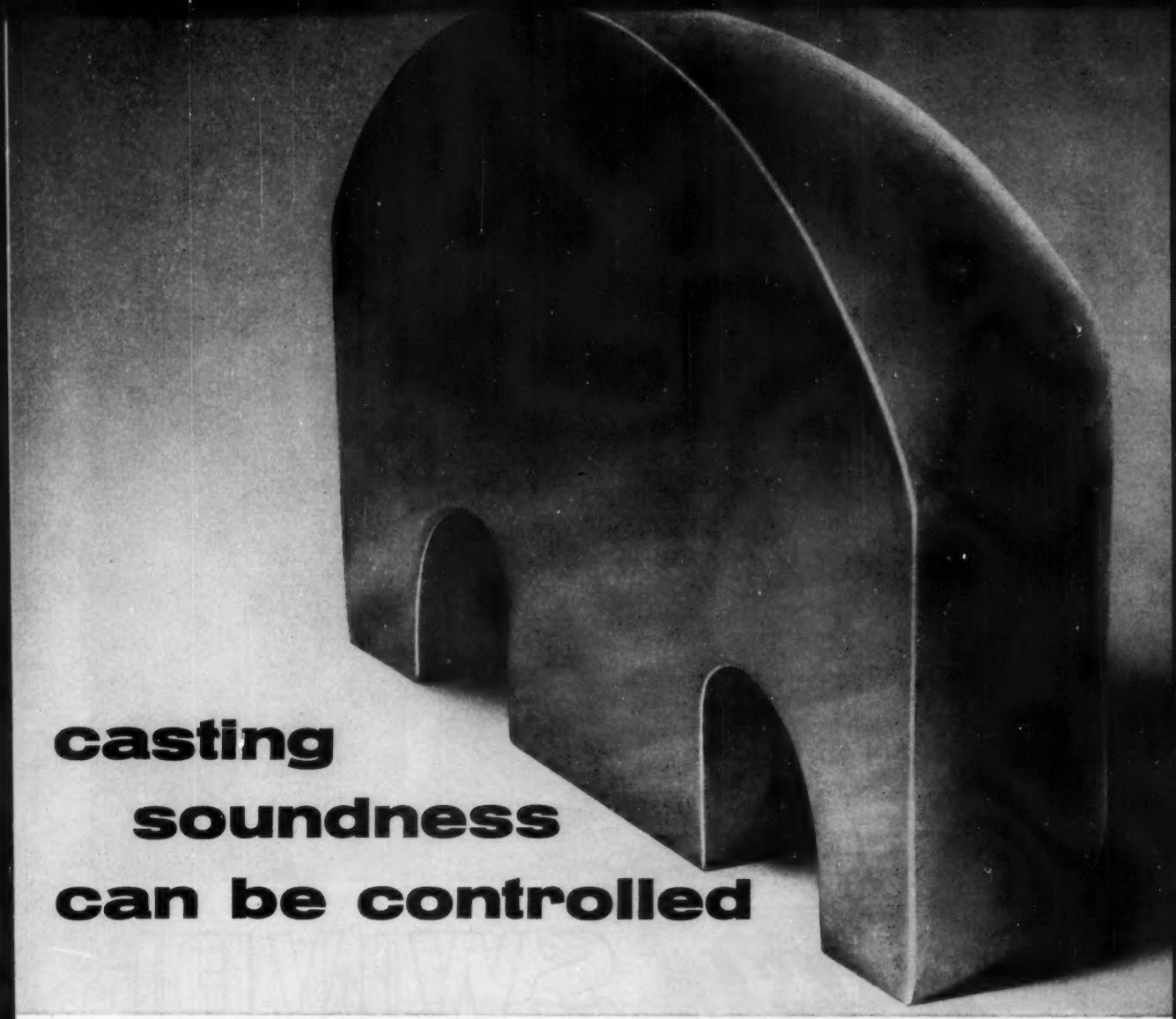
Because conventional materials fall short of these requirements, Armstrong engineers set out to develop a new type of gasket. Their work resulted in a new beater-saturated asbestos material—Accopac AN-890. This new gasket resists crushing under pressures of 100,000 psi at temperatures up to 350° F., and it has superior torque retention characteristics.

If you have a problem with gasket seals on aluminum flanges, our research may be helpful to you. We will be glad to make suggestions if you will submit details of your problem to us.

Much detailed information on other problems of gasket design, selection, and performance is contained in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7102 Dean St., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860–1960 Beginning our second century of progress

Please direct inquiries to advertiser, mentioning MACHINE DESIGN
Circle 469 on Page 19→



casting soundness can be controlled

Avoid risk of hidden defects . . . specify Meehanite castings

In castings of varying sizes and sections the control of metal structure is of paramount importance in preventing porosity and deviations in physical properties. Meehanite metal's dense, fine grain structure which assures casting solidity . . . free and easy machinability . . . and consistent physical properties regardless of mass or section is achieved by patented manufacturing methods quite unique in metallurgical control.

The uniform soundness of Meehanite castings is predictable in advance . . . in every casting . . . in every group of castings. You can depend on Meehanite to save you time and money in your shop and to enhance your products reputation in the field.

Avoid the risk of hidden defects which result in high machining costs and time loss. Don't take a chance on bargain prices or so-called "equivalents." Specify Meehanite castings and be free from worry. Whatever your casting requirements, there is a nearby Meehanite foundry ready to serve your needs.

For additional facts about Meehanite®, write to the Meehanite Metal Corporation, 714 North Ave., New Rochelle, New York, for your free copy of *Meehanite Means Better Castings.*

MEEHANITE METAL

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Casting Service Corp., LaPorte, Indiana and Bridgman, Michigan
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
Hamilton Foundry Inc., Hamilton, Ohio
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Oil City Iron Works, Corsicana, Texas
Palmyra Foundry Co., Inc., Palmyra, N. J.
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Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
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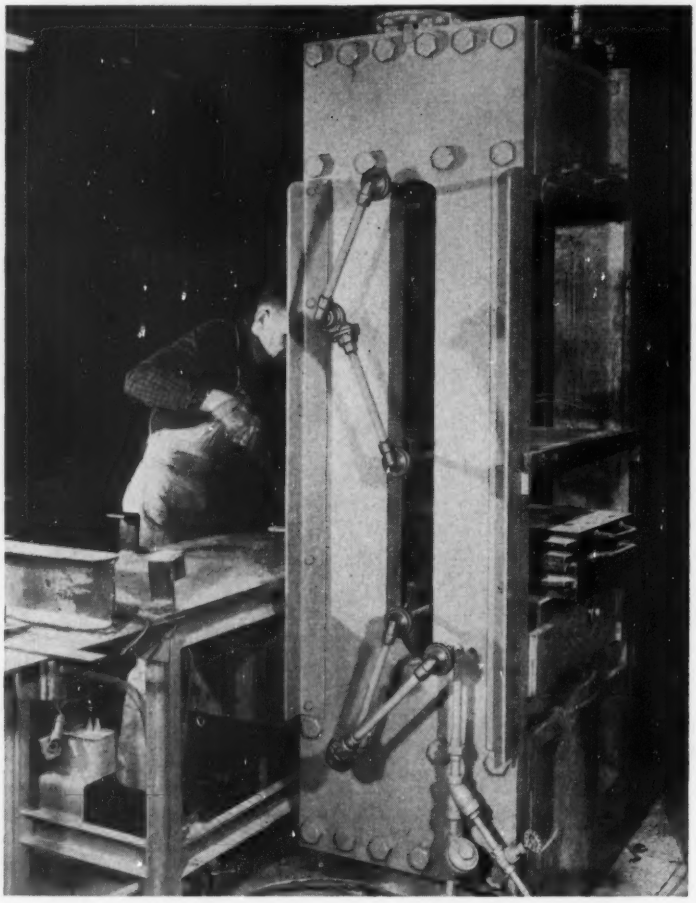
Otis Elevator Co., Ltd., Hamilton, Ontario

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

STEEL LINES FOLD LIKE AN ACCORDION
Typical of diverse swivel joint applications, newly designed Chiksan Discpak joints are installed on the steam lines of a platen press. This new type swivel joint, designed for hot gas and steam, allows inexpensive packing replacement without removing swivel joint from line.



WHEN *design*
DICTATES
METAL LINES . . .

SOLVE LINE FLEXING PROBLEMS

with **CHIKSAN SWIVEL**

Chiksan swivel joints allow metal lines to be flexed in predetermined travel arcs, eliminate hose rupture, reduce maintenance and replacement costs.

Where tight bends in pressure hose make wide loops necessary, Chiksan swivel joints, conversely, permit compact placement of lines. When used with hose, Chiksan swivel joints shorten hose lengths and also lengthen hose life by minimizing tight bend and torsional fatigue.

Chiksan swivel joints are available from stock in a wide range of materials, temperatures, and pressures to meet practically every design requirement. Chiksan swivel joint packing units are designed for specific services. For example, packings have been developed to efficiently handle non-inflammable hydraulic fluids. Write today for catalog and name of nearby sales engineer.

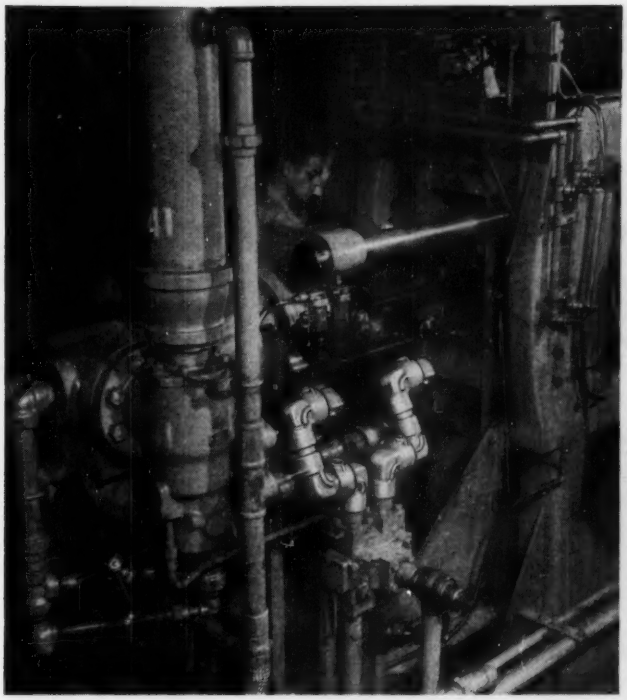
LONG SERVICE LIFE ➤
Chiksan swivel joints deliver years of service with only occasional maintenance attention. All-steel hydraulic lines on Flash-Butt welder, shown at right, allow lines to shift as machine is adjusted to handle various work.

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

fmc **CHIKSAN**

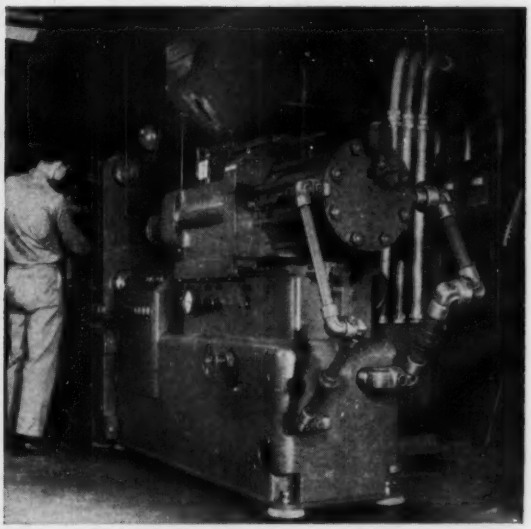
CHIKSAN **CHIKSAN COMPANY**—BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries Chiksan Export Company • Chiksan of Canada Ltd



NO HOSE BURST DANGER HERE...

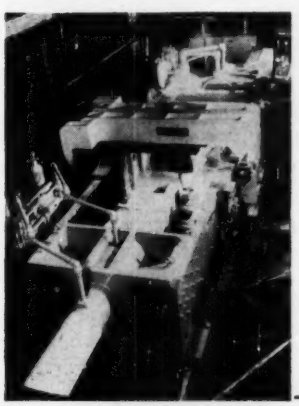
Critical lines take on a new measure of safety with all-steel flexible units replacing pressure hose. These all-metal swivel jointed lines shown on a die casting machine above, eliminate damaging hose ruptures, and reduce fire hazard, fluid loss and setup time by 75%.



PRESSURE? TEMPERATURE? CHIKSAN MEETS THE NEED...

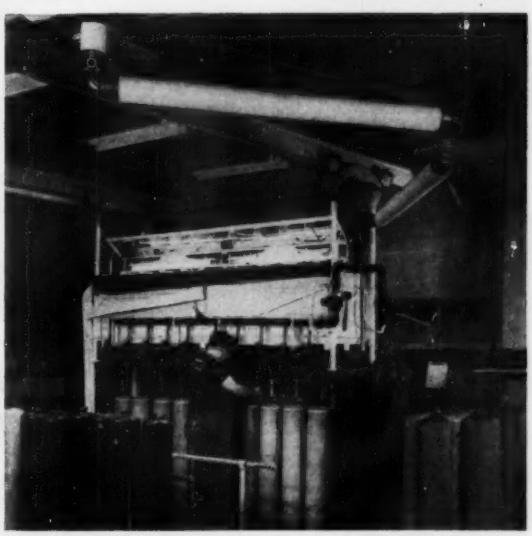
Over 2,000 different types, styles and sizes in a variety of temperature and pressure ratings are available to meet your design needs. This plastic injection molding machine, above, uses two different sizes of Chiksan swivel joints on its hydraulic lines.

JOINTS



NO LIMIT ON LINE DESIGN

Free swiveling action in 1, 2 and 3 planes permits design of compact lines to meet any requirement. This overhead line in service at a water softener regenerating plant permits shift from one setup of tanks to another for faster handling of tank regeneration.



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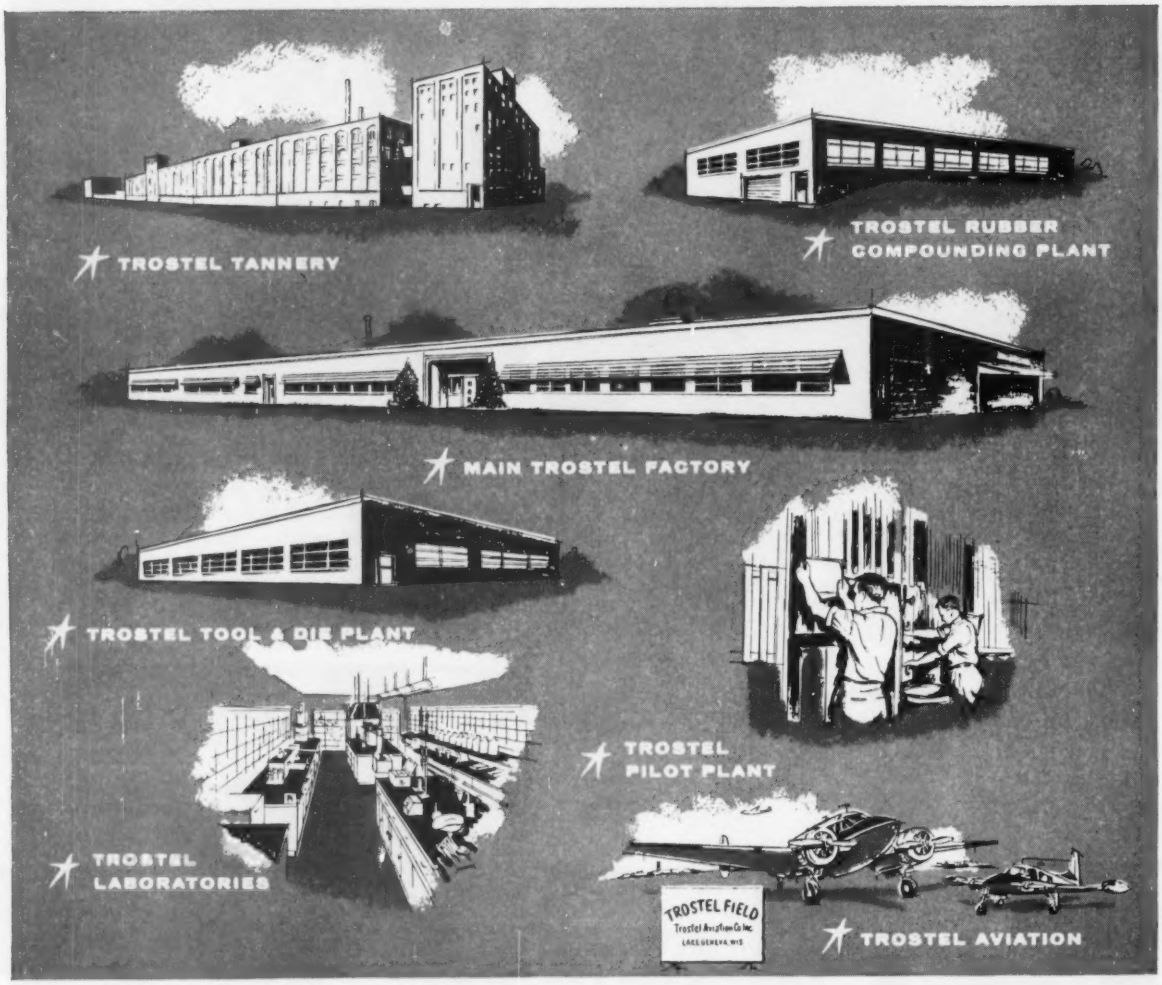

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From raw materials to finished product, all key sources of supply and manufacture are Trostel owned and operated. Leather is tanned at the Trostel Tannery. Rubber is compounded at the Trostel Compounding Plant. Dies are made at the Trostel Tool and Die Works. Three separate Trostel Laboratories conduct research in leather, impregnations, and synthetics. A pilot plant tests all production runs. When, therefore, parts and materials arrive at the point of manufacture into seals and packings they are uniformly standard in specifications. Manufacture itself is by automatic machinery in a modern plant, with a quality control system that insures close-tolerance accuracy in all operations. Special delivery and service are provided by Trostel Aviation . . . we can come to you quickly, or bring you to us.

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PACKINGS
OIL-SEALS
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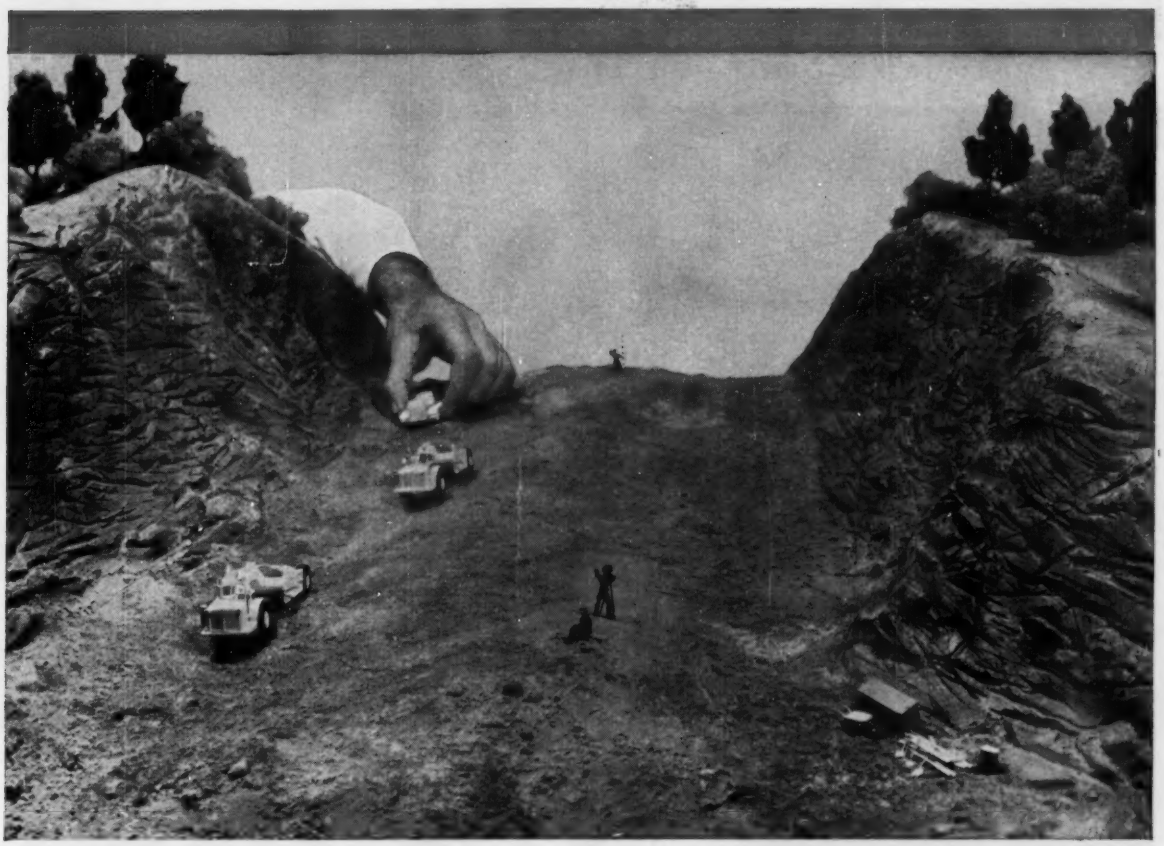
Circle 471 on Page 19



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Scale model illustrated built to 3.5 mm scale.

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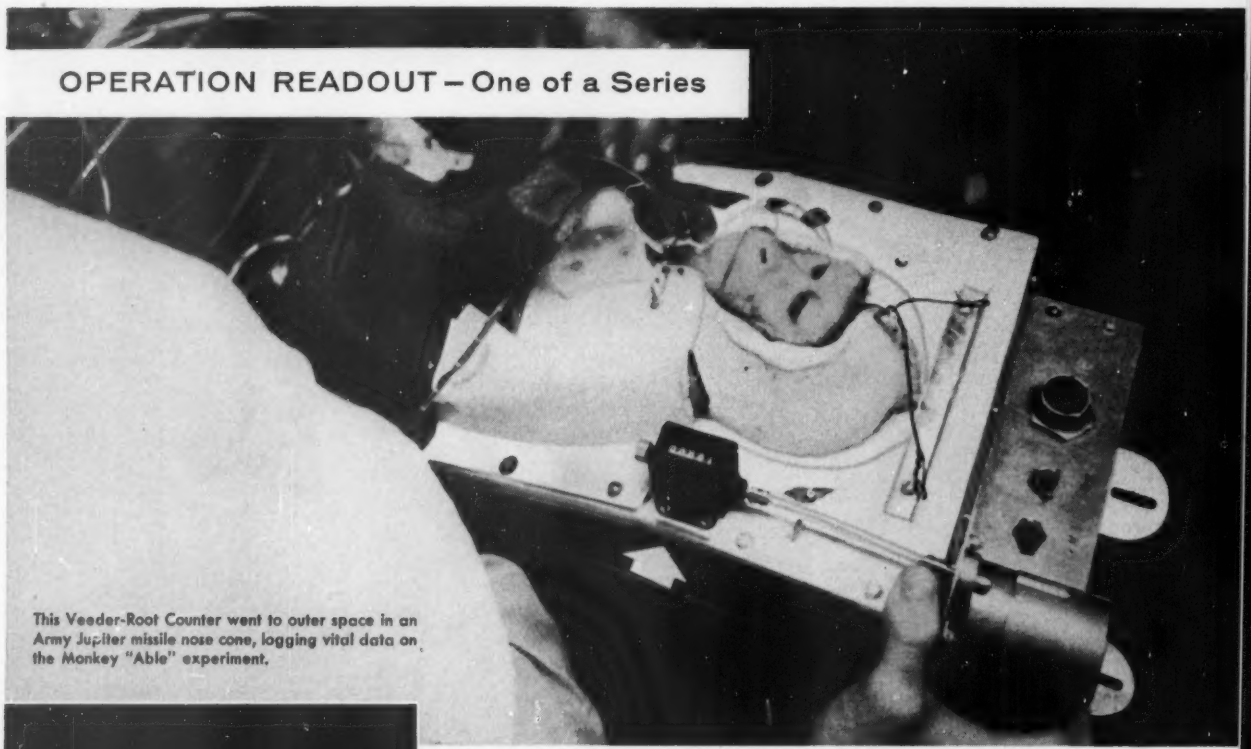
CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

OPERATION READOUT – One of a Series

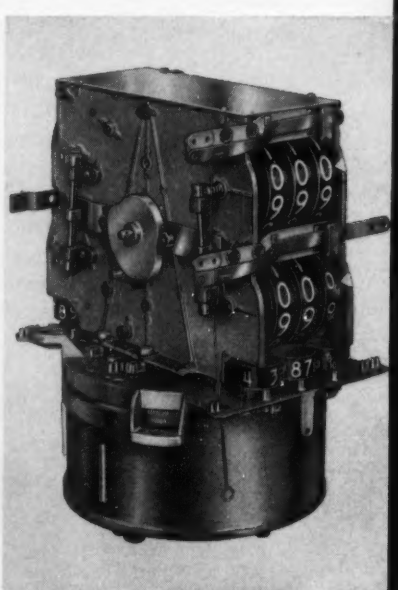


This Veeder-Root Counter went to outer space in an Army Jupiter missile nose cone, logging vital data on the Monkey "Able" experiment.

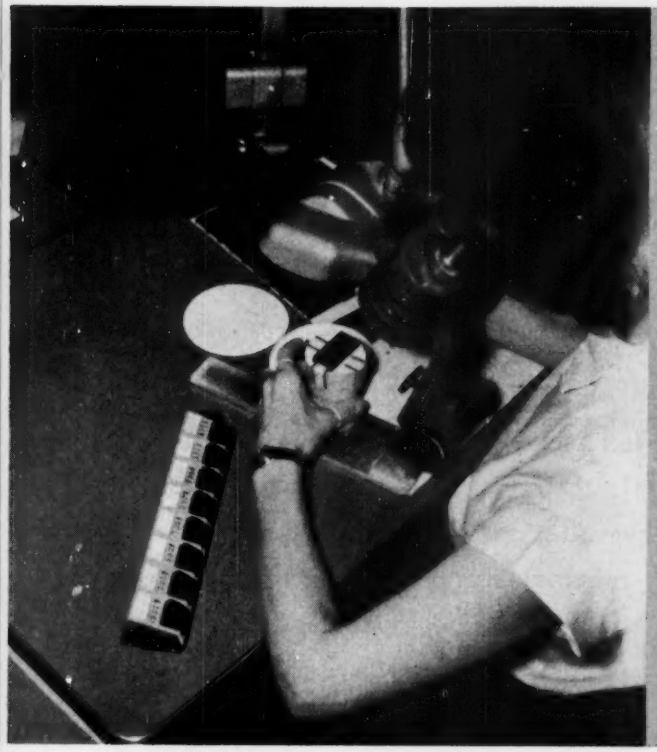
Everyone

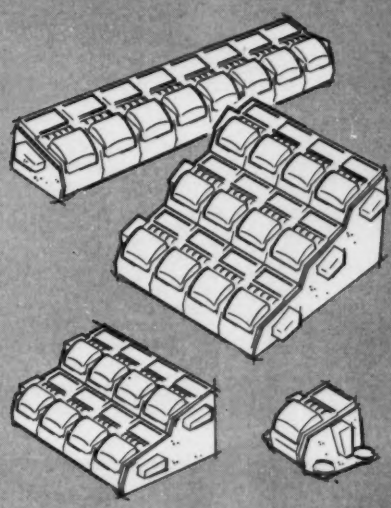
Veeder-Root Counters used as Mileage Recorders provide control data for modern elevator operation. Information is used to plan preventative maintenance, and reduce downtime.

Veeder-Root Electromagnetic Counters give both a continuous and totalized report on tolerances, for this recently developed Taft-Peirce automatic gaging system. Eight different sets of dimensions are recorded.



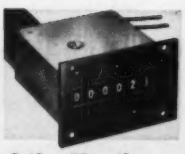
The "Head for Figures" is this famous Veeder-Root Computing head for gasoline pumps, used the world over. It typifies advanced applications of readout and automatic control.





The Veeder-Root VARY-TALLY is a versatile, low-cost reset counter for faster, more accurate hand tallying. Provides positive, easy-to-read record of units, parts, inspection, paperwork, sampling. Available in single units, strips, tiers or any combination.

Counts on Veeder-Root



Veeder-Root Counters of the Month

New! 360° Tape-Type Bearing Counter was developed to provide digital readout of angular relationship. Tape greatly reduces size and weight over conventional devices. Adaptable to many indication requirements.

Series 1591 Quick Reset, High Speed Magnetic Counter is designed for accurate, dependable remote indication of machine operation, or for counting at high speed. Speed: 3000 cpm, 4 or 6 figures, manual or electrical reset.

From outer space to the local gasoline pump, Veeder-Root helps communicate important information. How much? How often? When? How fast? Where? How long? Which direction? What position? . . . all these questions are answered easily, simply, quickly and directly through Veeder-Root's concept of digital communications . . . OPERATION READOUT.

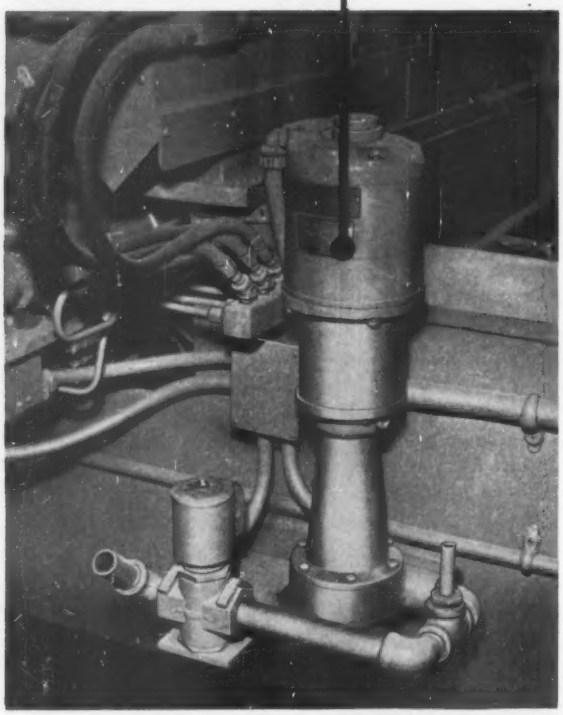
Operation Readout helps you take full advantage of the newest and most advanced counting techniques. It is based on modern uses of Veeder-Root Counting devices, from the simplest type of ratchet counter to the most sophisticated designs of Remote Data Readout, Navigational Counters and Computer-Blender Pump Controls. Through these counters, digital communication and control can provide important advantages in speed, accuracy, human engineering, comprehension and operational control.

Veeder-Root's "Operation Readout" can help you, now! Whatever your indication, readout or counting problem, Veeder-Root offers a century of experience in counting engineering. There are over 400 specific models in stock, ready for prompt shipment, or a special counting or readout device can be developed for your application. Contact your nearest Veeder-Root Counting Engineer or write direct.

VEEDER-ROOT, HARTFORD 2, CONNECTICUT *"THE NAME THAT COUNTS"*

New York • Chicago • Los Angeles • San Francisco • Seattle • St. Louis • Greenville, S. C. • Altoona, Pa. • Montreal • *Offices and Agents in other principal cities*

. . . pumps for machine builders



In their 100 years of pump progress, Ingersoll-Rand has established a reputation for solving liquid movement problems for machine builders. Famous I-R engineering is unmatched anywhere . . . whatever your design requirements for mounting, flow or pressure, there are thousands of models and types to choose from . . . or we'll make one to suit your most exacting need.

Why not check with the world's foremost centrifugal pump builder regarding your pumping problems. You can get complete details from the pump specialist at your nearby I-R branch office—or direct from our New York headquarters.

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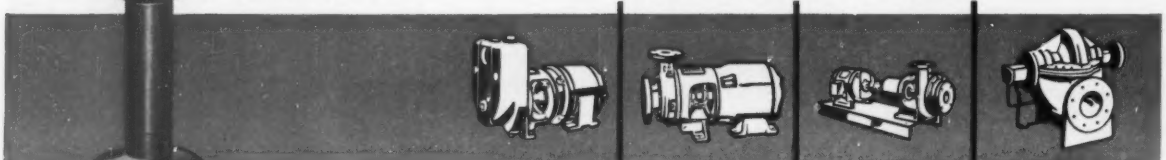

Self-priming pumps | Motorpumps | Cradle mounted pumps | Horizontally split pumps

Circle 474 on Page 19

DU PONT IMPROVES

VITON®

SYNTHETIC RUBBER

- NOW GIVES TWICE THE SERVICE LIFE AT 600°F.
- OFFERS GREATER RESISTANCE TO CHEMICALS AND SOLVENTS

VITON'S remarkable resistance to heat and fluids has already improved performance of components for appliances, autos, aircraft and many types of industrial equipment. Now the ability of this new synthetic rubber to withstand heat and chemical exposure has been extended to even greater limits. Here are some of the properties of the new high-performance grade, now commercially available in a wide range of products.

Improved resistance to heat aging—When oven-aged in air at 400° F. or less, VITON vulcanizates now remain usefully elastic for *indefinite periods*. At higher temperatures, they can be expected to remain usefully elastic for more than:

3000 HOURS @ 450° F.
1000 HOURS @ 500° F.
240 HOURS @ 550° F.
48 HOURS @ 600° F.

Improved resistance to fluid exposure—VITON now has better resistance to nitric acid, glacial acetic acid and hydrochloric acid, as well as to certain aromatics and diester lubricants. Its proven resistance to a wide variety of oils, solvents, fuels and chemicals remains unequalled among synthetic rubbers.

Complete information—Learn more about VITON, and how it can improve the products you make and use. Technical literature just published will give you all the facts. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Dept. MD-2, Wilmington 98, Del.

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SYNTHETIC RUBBER
NEOPRENE HYPALON® VITON® ADIPRENE®

Better Things for Better Living . . . *through Chemistry*

OTHER IMPORTANT PROPERTIES OF VITON

Hardness: 60 to 95 durometer on the Shore A scale.

Tensile strength: 2000 to 3000 psi. at room temperature, with elongation from 100% to 400%, depending on hardness; at 300° F., tensiles of 300 to 1000 psi., with elongation from 80% to 200%.

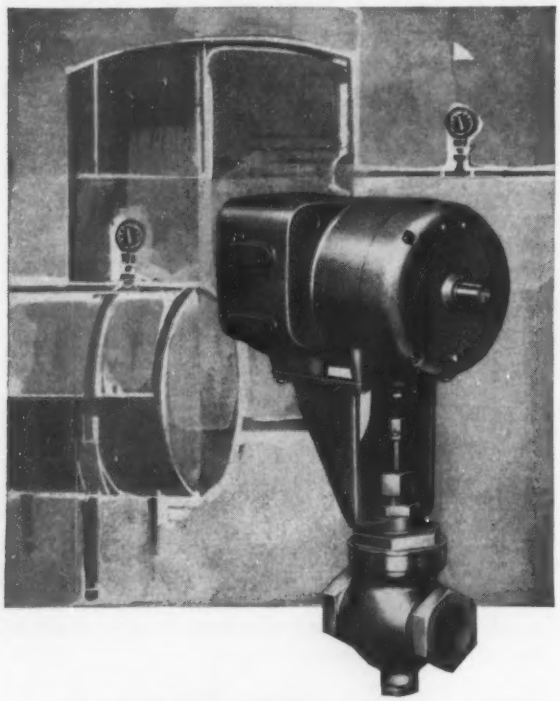
Compression set: VITON vulcanizates recover to within 90% to 97% of original dimensions when compressed 25% and held at 250° F. for 70 hours.

Low temperatures: Specimens 0.075 in. thick have a Young's modulus of 10,000 psi. at −20° F. and a brittle point of −47° F. A 0.010 in. thick coating of VITON on wire did not crack at −90° F., when bent around a mandrel 10 times the diameter of the wire.

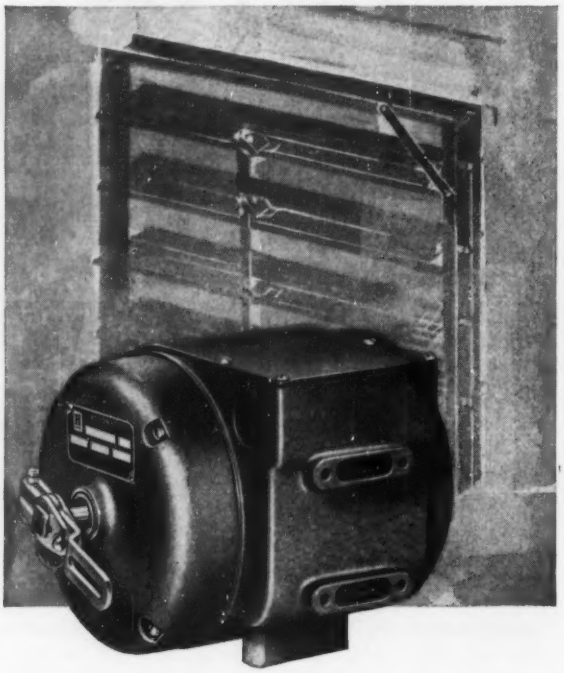
Ozone and weather: VITON has withstood 28 days in 100 ppm of ozone, without a crack! After twelve months' exposure to direct Florida sunlight, it still remained in perfect condition.

Electrical: Typical values—DC resistivity of 1.4×10^{14} ohm-cm; specific inductive capacity of 8.53; power factor of 2.5%; dielectric strength of 412 volts/mil.

OPERATE ANY SLIP STEM OR ROTARY STEM VALVE



OPERATE ALL INDUSTRIAL TYPE DAMPERS



more torque! more precise positioning for industrial valve and damper applications *New Honeywell*

ACTIONATOR heavy-duty electrical control motors*

Use these compact, powerful new industrial motors in dairies, breweries, water works—for ovens and cooling towers—wherever highly accurate modulating or two-position control is required.

Some models operate vertical-acting stem valves having lifts of from ½ to 1½ inches. The double-ended shaft can also simultaneously operate rotary stem valves, butterfly valves and other devices through suitable linkages. Other models operate rotary-shaft type valves, dampers, louvers and other final control elements.

ACTIONATOR control motors are available with two-position, floating or proportional control, and with a variety of speeds from 7.4 to 120 seconds full-stroke operation. Torque ratings range to 200 inch/lbs.

Additional features include built-in linkage and strain relief, a mounting yoke and enclosed terminals with gasketed housing to meet JIC specifications. Also available are models that include cam-operated internally mounted switches for a variety of sequencing switching purposes.

For complete information, call your local Honeywell office. Or write Minneapolis-Honeywell, Dept. MD-2-54, Minneapolis 8, Minnesota. In Canada, Honeywell Controls Limited, Toronto 17, Ontario.

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First in Control

SINCE 1885

See us in Sweet's 1960 Product Design File, Section 5b-Min.

HARD TO HANDLE
chemicals, fuels, and solvents

Special materials to tame tough fluids

Handling volatile and chemically reactive liquids is a critical problem requiring very selective use of materials in the manufacture of component parts which control, meter, pump or contain these liquids. Tough corrosive problems, as well as great extremes of temperature must often be overcome.

Among the many strategic materials, Chicago-Allis designs and custom molds into component parts for O.E.M. customers, are the fluorocarbons (DuPont's Viton-A, Dow Corning's LS-53 and 3M's Flurel) specialty synthetic rubbers, and impregnated leathers. Parts made from these materials provide the resistance and durability needed for manipulation of jet fuels, high octane gas, diesel and heating fuels, commercial solvents, chemicals and many other fluids used in a wide range of industries.

Chicago-Allis has the experience to design and manufacture mechanical seals, custom molded rubber and leather products for use in a wide range of service conditions and environments. Extensive production, experimental and engineering facilities are always at your disposal to help with your component parts requirements. Send for complete catalog information.

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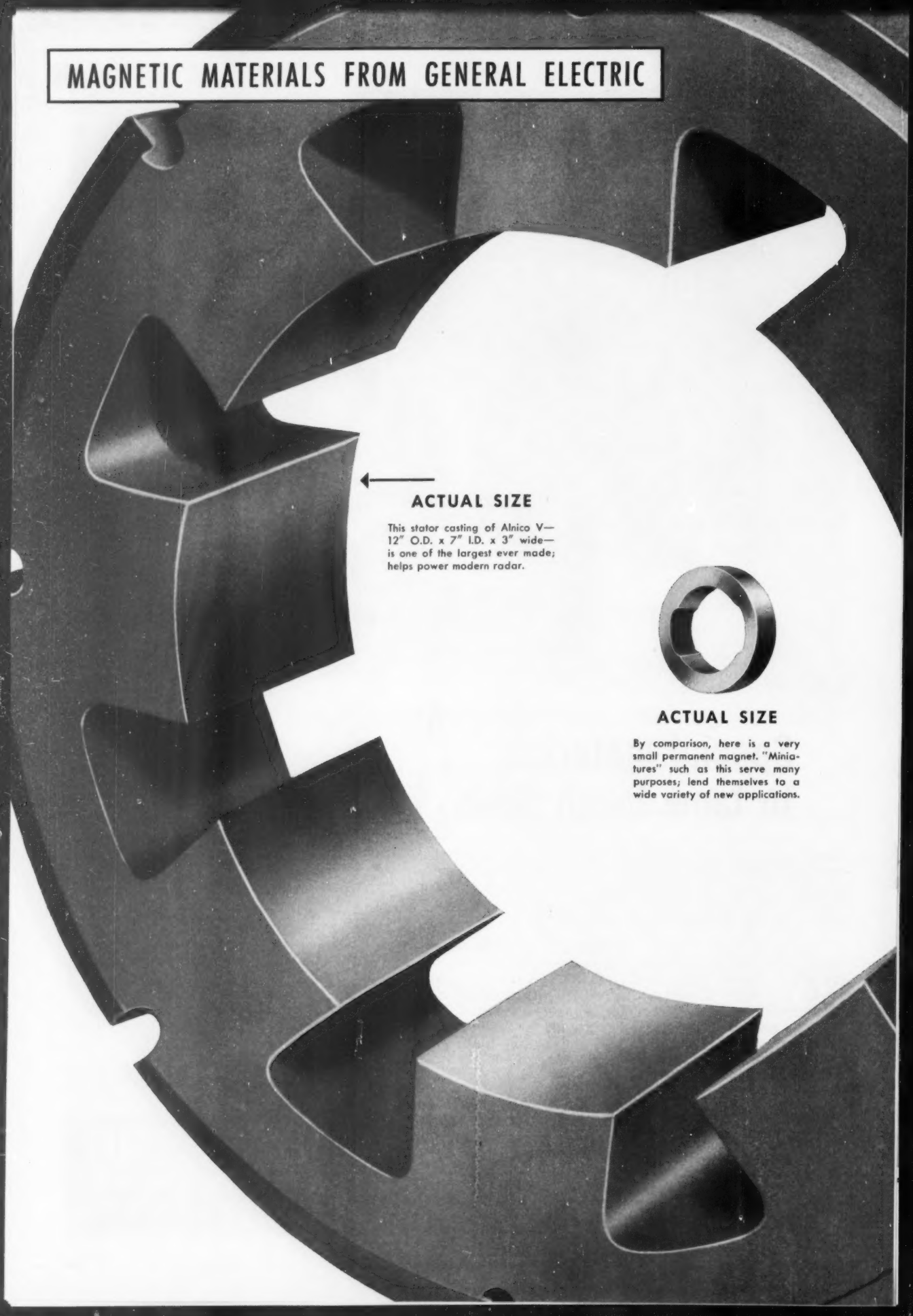
Engineers · Designers · Manufacturers

MAGNETIC MATERIALS FROM GENERAL ELECTRIC



ACTUAL SIZE

This stator casting of Alnico V—12" O.D. x 7" I.D. x 3" wide—is one of the largest ever made; helps power modern radar.

ACTUAL SIZE

By comparison, here is a very small permanent magnet. "Miniatures" such as this serve many purposes; lend themselves to a wide variety of new applications.

How G-E permanent magnets help power everything from toys to radar systems

Magnetic Materials Section reports on the new range of permanent magnet sizes . . . and on what it means to motor design

Shown here, in actual size, is one of the largest single-piece permanent magnets ever cast. It is a vital component in today's most advanced radar systems.

Also shown is one of the *smallest* permanent magnets on the market. It helps power a toy motor.

These General Electric magnets illustrate a growing trend in motor design . . . the replacement of motor wound fields by permanent magnets.

There are many reasons for this trend. Increased power is one of them. Permanent magnet power is constant and reliable. It requires no outside excitation or external regulating equipment. Permanent magnets cost less; reduce weight and space; have long life.

Little wonder that General Electric permanent magnets are becoming a big factor in motor design. Whether your present interest is in motors, generators, controls, magnetic separators, or holding devices, there's a G-E permanent magnet that can cut costs, weights, and space—give you better performance, too.

For further information—or for the assistance of a General Electric engineer—write: *Magnetic Materials Section, General Electric Company, 7826 N. Neff Ave., Edmore, Michigan.*

MAGNETIC MATERIALS SECTION

GENERAL ELECTRIC

CARBOLOY® CEMENTED CARBIDES
MAN-MADE DIAMONDS • MAGNETIC MATERIALS
THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

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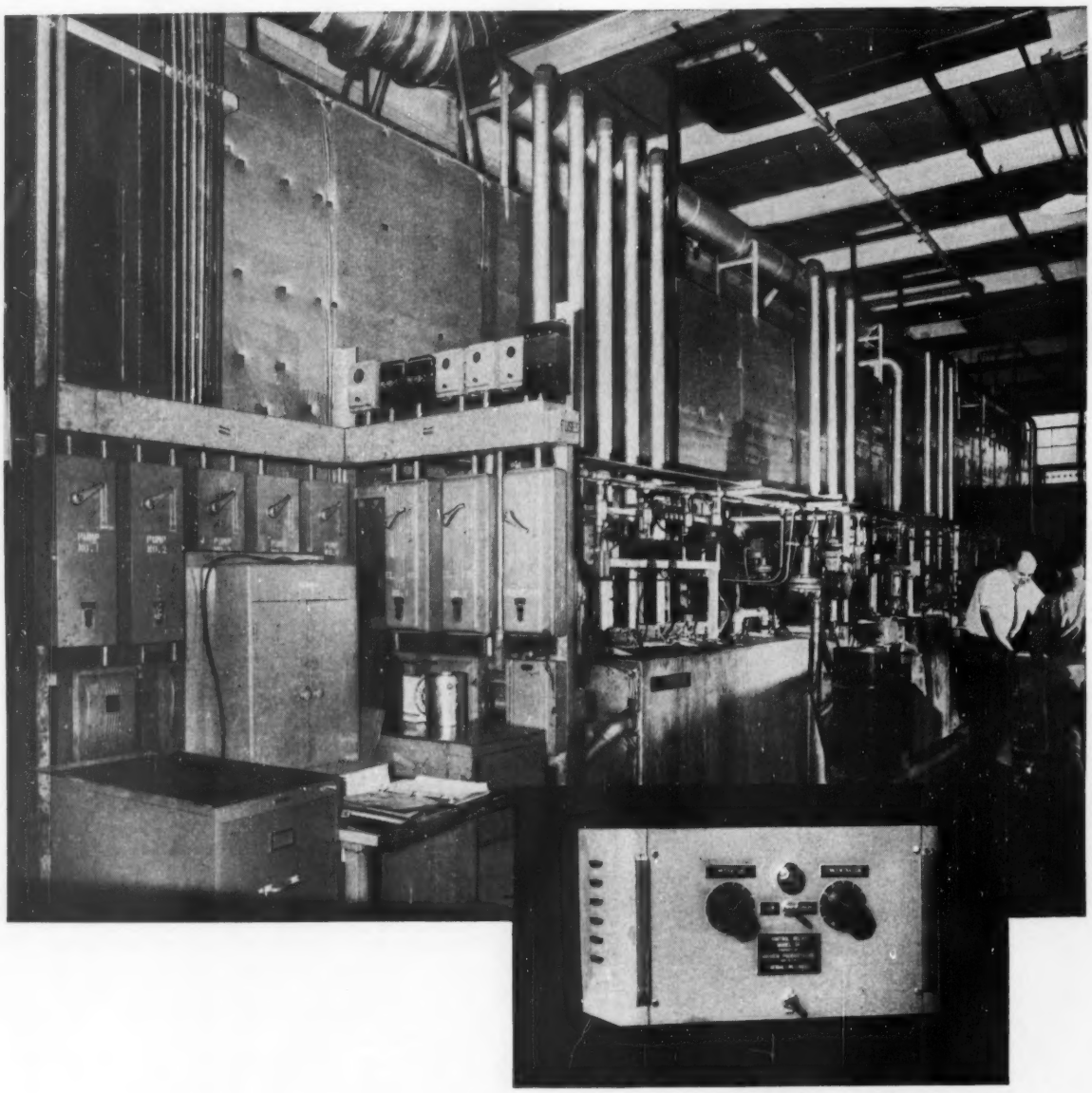
AMCHEM AUTOMATION...a new



Many industry leaders in iron, steel and aluminum fabrication are already employing AMCHEM AUTOMATION to provide unmatched product protection and gratifying production savings to these products—aluminum siding, appliances, venetian blinds, fluorescent lighting fixtures, aluminum sign blanks, steel office furniture, automotive trim, aluminum windows and doors. Give your product the same protection, the same kind of savings — with AMCHEM AUTOMATION!

concept in chemical conversion coatings assures you constant, uniform quality, actually saves you money!

AMCHEM AUTOMATION means new standards of protection for your metal products with actual black-and-white savings in time and money you can't afford to ignore!

AMCHEM AUTOMATION takes the human element out of your conversion coating processing—replaces it with 100 percent electronic line control that virtually assures you of constant, uniform quality. Rejects due to faulty bath control plunge to new lows. Product assembly moves faster through inspection as AMCHEM AUTOMATION guards quality round-the-clock!

AMCHEM AUTOMATION releases quality control personnel to other duties, builds employee morale and pride in their work. AMCHEM AUTOMATION watch dogs chemical replenishment—bath is never overloaded or under strength. You reap big savings in time, labor and chemical costs!

AMCHEM AUTOMATION can be yours right now for metal pre-treatment and protection on a variety of fabricated products. Just say the word, we'll have an Amchem Automation Coordinator—a specialist in electronic line control—fill you in on all the time, money and labor saving details!

AMCHEM

AMCHEM PRODUCTS, INC.

(Formerly American Chemical Paint Co.)

First in automated chemical conversion processing

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

Amchem is a registered trademark of **AMCHEM PRODUCTS, INC.**

The physical characteristics of CLAD-REX® vinyl-metal laminate

The use of vinyl-clad metals is growing rapidly. The type and variety of vinyl-clad metals is increasing also. Although the various vinyl-clads compete for attention, they are not alike. Nor do they deliver similar advantage.

Therefore, your vinyl-clad metals data file should be assembled with care. Know exactly what you are considering, when to use it, and how.

At present there are two basic types of vinyl-clad metal available. One is a plastisol which is roller coated or sprayed on the metal substrate in liquid form. The other is a calendered vinyl film which is laminated to the metal substrate. Various levels of quality exist within both areas. However, the laminated type generally offers substantially broader advantage to the user than the plastisol—primarily within the areas of styling.

Because the characteristics can obviously vary in degree with the gauge of metal and film as well as texture and pattern of film, the following tabular data must be considered as typical:

Results of Physical Tests

Characteristic	Properties of Film (8 Mil)	Properties of Laminate
Ultimate Tensile	4400 psi	Tensile of Supporting Metal
Ultimate Elongation	170%	Elongation of Supporting Metal
Tear Strength	910 lb. in.	Dependent on Metal Gauge
Bend Brittle, ¼" rod	—5° C.	—30° C.
Reverse Impact	Tears	120 in.—lbs.
Heat Deformation at 120° C. 2000 g. load	32%	30% (1 side)
Shrinkage 5 min. at 250° F.	4.6% with cal. grain	0.6%
	1.6% cross cal. grain	None

The corrosion resistance of Clad-Rex vinyl-metal laminate

The poly-vinyl chloride film used in Clad-Rex offers unusual resistance to chemicals. It will withstand acids, alkalis, alcohol, household detergents, salt water, industrial liquids, petroleum and corrosive atmospheres.

Results of Corrosive Tests

Agent	VINYL-METAL LAMINATE		PHENOLIC		ALKYD	
	Days Exp.	Result	Days Exp.	Result	Days Exp.	Result
10% Sulfuric Acid	17	OK	2	Failed	2	Failed
10% Nitric Acid	17	OK	2	Failed	2	Failed
10% Hydrochloric Acid	17	OK	2	Failed	2	Failed
10% Acetic Acid	17	OK	2	Failed	2	Failed
10% Lactic Acid	17	OK	17	Failed	2	Failed
10% Formaldehyde	17	Swelled	2	Failed	2	Failed
10% Caustic Potash	17	OK	3	Failed	2	Failed
Distilled Water	17	OK	17	Failed	2	Failed
Mineral Oil	17	OK	17	OK	17	OK
Ethanol	17	Sl. Shrink	17	OK	17	OK

The durability of Clad-Rex vinyl-metal laminate

Although the sales appeal of unlimited styling is a major factor, perhaps the most important advantage offered by Clad-Rex vinyl-metal laminates is their durability. Clad-Rex *is* practical to fabricate. It can be processed in almost as many ways as any *un*finished sheet metal—including deep-drawing.

Results of Abrasive Tests

Coating	Mils Film Thick	Total Revolutions	Revolutions Per Mil Film Thick.*
Vinyl-Metal Laminate	4.0	8,430	2,108
Vinyl-Metal Laminate	8.5	17,156	2,100
Phenolic	1.25	1,204	1,000
Urea-Alkyd	1.70	122	72
Vinyl Lacquer Coating	2.0 Ave.	703-954	351-477

*Abrasion resistance determined with a Taber Abrader using a CS-10 wheel.

The cost advantage of Clad-Rex vinyl-metal laminate

As a purchased material going into a users plant, vinyl-metal laminates cost more than unfinished or some other prefinished metals. *But, most important, end products made of Clad-Rex generally cost less!* The reasons are worthy of close examination:

1. Parts made of Clad-Rex require no further finishing. This means a savings in original equipment (including maintenance), finishing material, factory floor space, labor, handling, etc.

2. The abrasion resistance of Clad-Rex substantially reduces and often eliminates rejects. This means a savings in rejected products, handling and expensive reworking activities.

A source of engineering and manufacturing service for you

Clad-Rex interest in helping you extends into your own plant. A Clad-Rex Fabricating Engineer is provided to show your production people how easy it is to process Clad-Rex.

Furthermore, Clad-Rex operates a fully staffed and equipped research laboratory. Its facilities are devoted to customer service as well as improving Clad-Rex itself.

Write and describe your product. See how Clad-Rex can work its broad effect on industrial design, engineering and selection of pre-finished metals in your product.

VINYL-METAL LAMINATES BY CLAD-REX DIVISION OF SIMONIZ COMPANY
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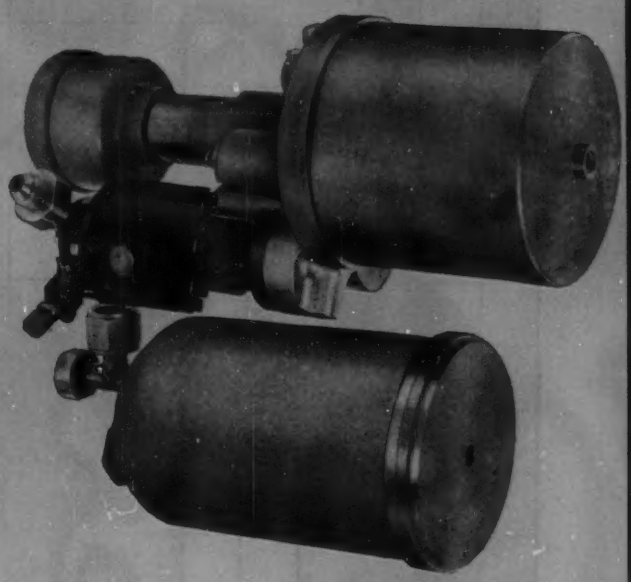
FLIGHT HARDWARE...NOW

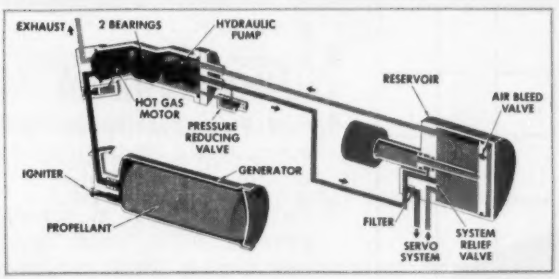
VICKERS HOT GAS AUXILIARY POWER SYSTEMS

for missiles and spacecraft



CONCEPT

Vickers piston motors — as used in virtually all existing commercial and military aircraft — are now modified to operate efficiently on propellant-generated hot gas, or bleed gas from the main propulsion system. Minimum weight is achieved by mounting the hot gas motor "shaft-to-shaft" with a Vickers piston hydraulic pump in a common housing. The motorpump, a simple gas generator, hydraulic reservoir, filter, and relief valve are integrally mounted to form a complete Auxiliary Power System in a compact package.



DEVELOPMENT

Production line Vickers hydraulic motors have been operating on hot gas for over 2 years. Units have run on gases as hot as 2300°F without modification.

The present flight hardware was built and tested after an intensive prototype development effort. Test program motorpumps have accumulated over 100 runs each for 1 minute of operation cycle. Since the current development program is aimed at meeting known APS requirements, no limits have been established on the operating cycle duration for this type of equipment.

CONCLUSIONS

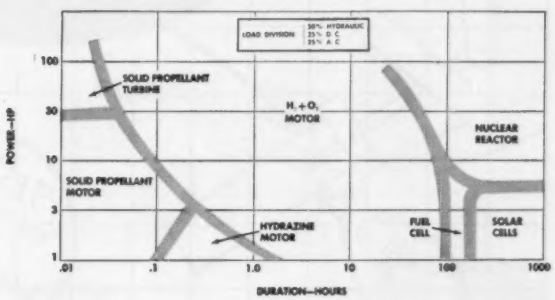
Performance and reliability goals for this concept have been met successfully. A complete hot gas APS package in the 2 - 8 horsepower range, shown above, is available within 90 days. Customer specifications for these and larger systems are invited. Write for Bulletin A-5223B.

APPLICATIONS

Because of the increasing scope of APS applications, Vickers conducted a series of studies to establish criteria for APS selection. Recent study results (published in March, 1959) indicate that for short duration operation, hot gas motors offer the best weight advantage in the 1 to 30 hp range. See curve below.

Attractive reliability and early delivery resulting from extensive use of proven hardware may extend the application of these systems to an even greater range of second and third generation missiles and spacecraft. Additional advantages include: low speed equipment (up to 10,000 rpm), convenient ground checkout, growth potential, and no alert time required.

OPTIMUM WEIGHT NON-PROPULSIVE POWER SYSTEMS



VICKERS INCORPORATED

AERO HYDRAULICS DIVISION

DETROIT 32, MICHIGAN

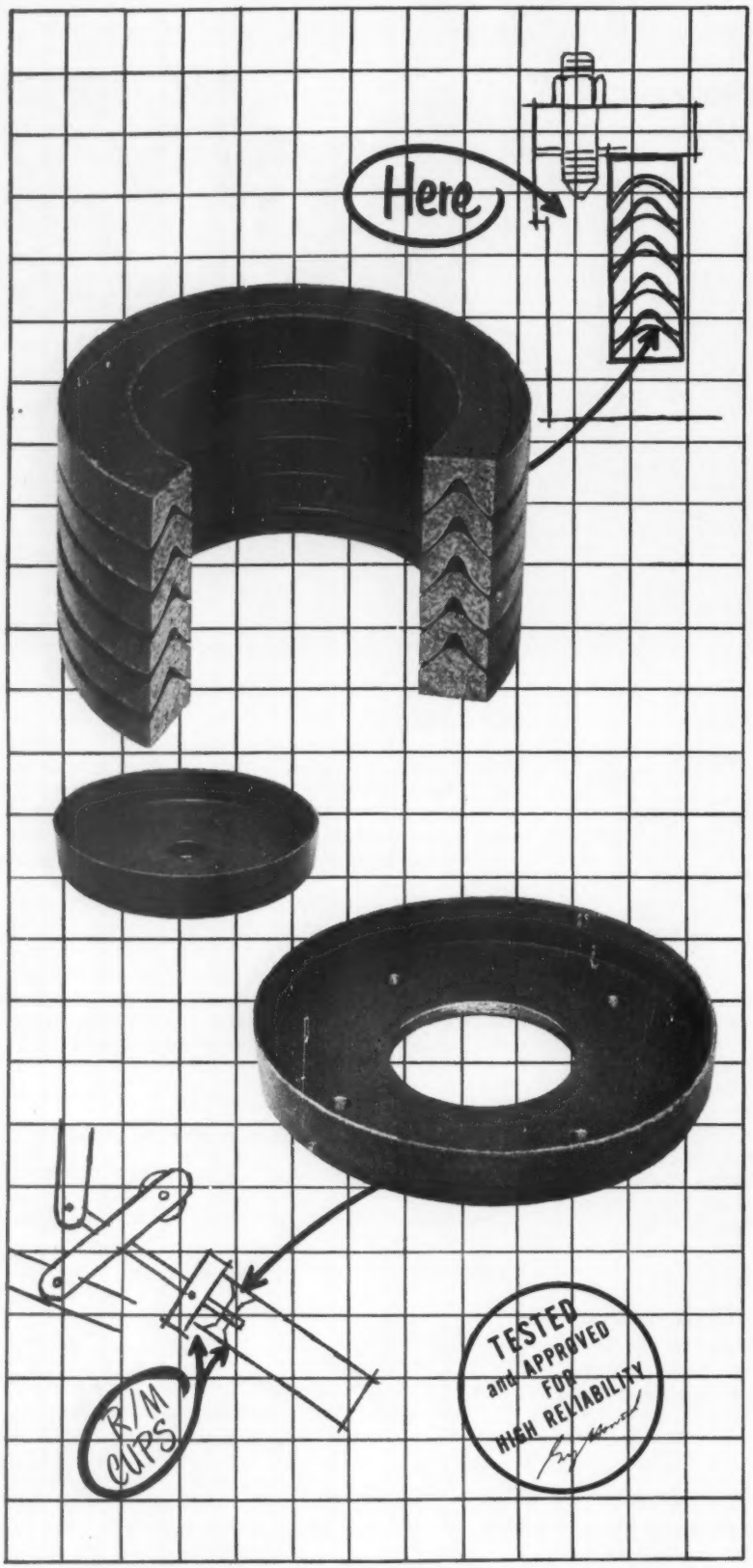
division of:

SPERRY RAND CORPORATION

8386

Circle 482 on Page 19

Designers think of R/M first for asbestos, rubber,



NOW! R/M Vee-Flex® Packing Rings

and R/M Piston Cups

of Teflon*-impregnated asbestos fabric

. . . for temperatures to 500°F

. . . for all hydraulic fluids

Check these important advantages never before possible:

1. Minimum thermal expansion and plastic flow
2. Superior extrusion resistance
3. Broad chemical resistance
4. First V-ring packing capable of constant low coefficient of friction without aid of lubrication
5. Permits operation at temperatures of 500°F—under certain conditions to 650°F (elastomer-type V-rings are limited to 300°F)
6. High or low pressures are handled with one type of material

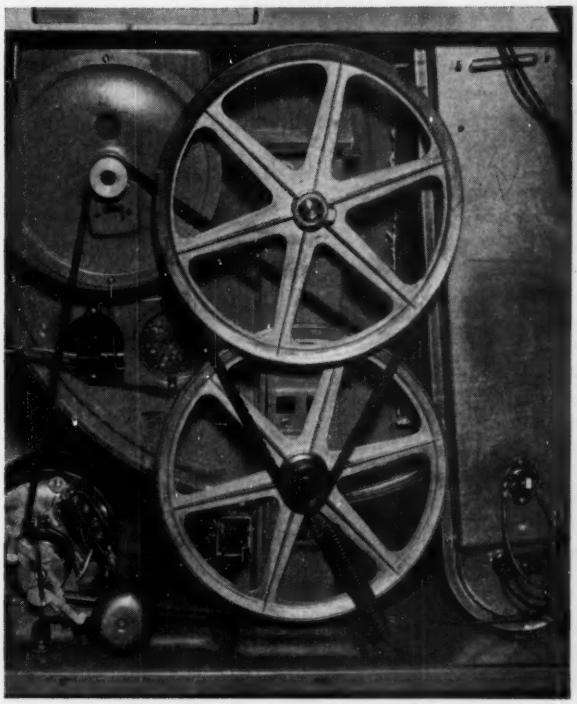
The first molded hydraulic and pneumatic packings to outperform all elastomer V-rings and piston cups

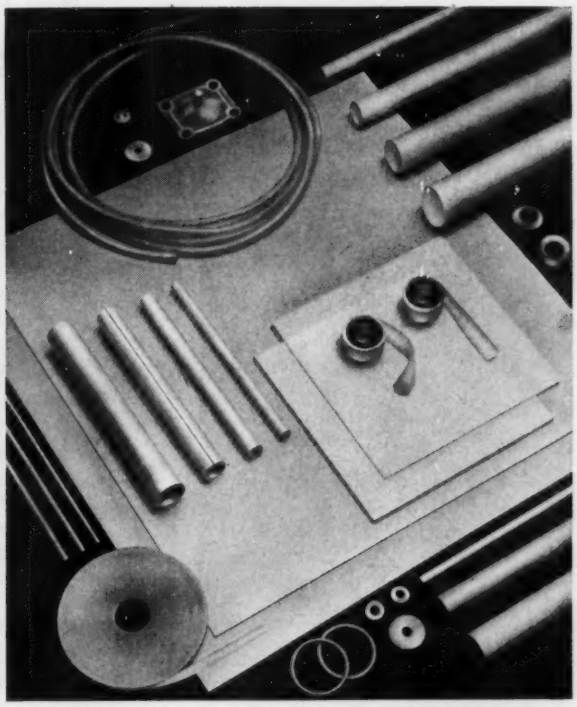
**Du Pont trademark*

PACKINGS

Get more information about these self-sealing, self-adjusting rings and piston cups. Ask for booklet P-8907. Packing Division, Raybestos-Manhattan, Inc., Passaic, N.J.

sintered metal, and engineered plastic products





CX MOLDED V-BELT

Outlasts Other Belts 8-1

The Only Belt of its Kind . . .
Fully Molded, Completely Jacketed Notched V-Belt

Ideal for small sheave diameters, short centers, high speeds

Micro-positioned strength member is supported in a "Power Arch" and locked into a homogeneous molded unit for perfect balance, cool, quiet, *vibrationless* operation. Locked-in length stability. Fully covered; prevents flex-cracking; maintains shape. Completely protected from atmospheric conditions; no ply separation; less wear on grooves. Let R/M rubber specialists work with you on V-belts, transmission or conveyor belting, rubber hose, molded or extruded parts.

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products. Manhattan Rubber Division, Raybestos-Manhattan, Inc., Passaic, N.J.

Now you can do even more with TEFLON—made *bondable* by R/M

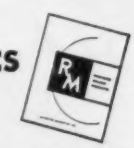
Time was, you'd often rule out "Teflon" where it was sorely needed, simply because you couldn't make it adhere to anything.

But not now. R/M has a process that makes "Teflon" easily bondable to other materials and to itself with commercial adhesives. Now, when designing with "Teflon," you don't need to include elaborate and costly fastening methods.

R/M can supply "Teflon" sheets, tubes and tape with bondable surfaces where you specify them. Thus you can use the unique combination of electrical and chemical properties of "Teflon" without worrying about how to make it stay put. In fact, you can take advantage of bondability and non-bondability in the same R/M "Teflon" part.

A lot is happening in "Teflon" daily. To keep up with it, talk "Teflon" with the R/M man and learn of R/M's complete "Teflon" service that can help you cut costs without cutting corners.

PLASTICS



For a copy of this booklet, full of information on R/M's complete line of "Teflon" Products, write Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charlestown, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Circle 484 on Page 19A

Circle 485 on Page 19A

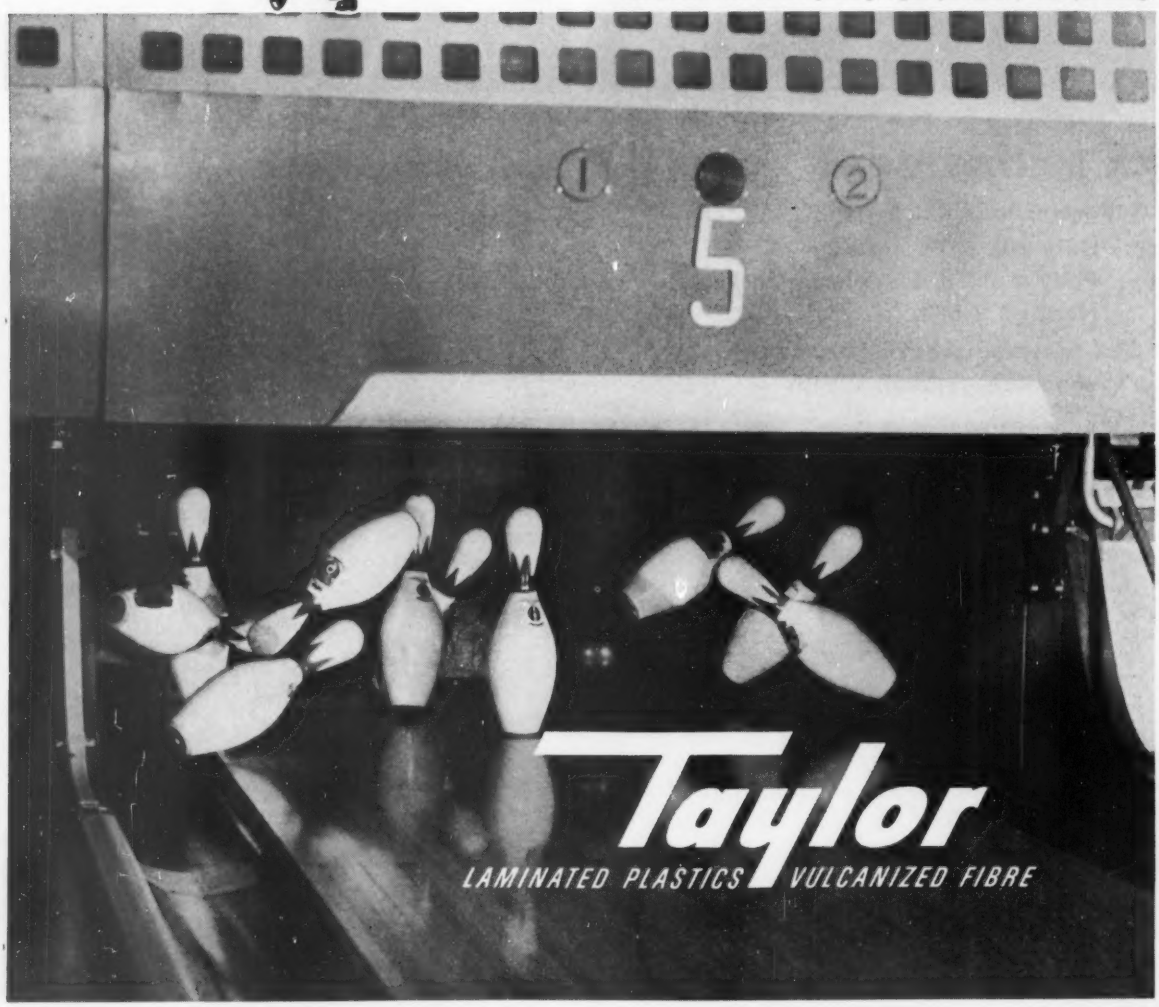
New "Taylorite"® is a veritable workhorse

Improved Vulcanized Fibre has new flexibility, new uniformity, new structural strength to fit it to even broader application in many fields

There has been a big change in Taylor Vulcanized Fibre, including the name. New processing equipment and atmosphere-controlled storage facilities have enabled us to make major advances in overall uniformity —from lot to lot and at no increase in cost to you. Taylorite has wide use as an insulating and structural material for electrical and electronic applications. But it is being put to service in many other ways, too. A good example is choice of Taylorite as kick-back plates in bowling alleys. Here it must withstand the constant pounding of flying pins without structural breakdown or damage to the pins. And it is doing its job perfectly.

Find out how new Taylorite Vulcanized Fibre can help improve your products and cut costs. Send for samples. Test them for yourself. Put them under tension, flex them, compress them, form them. You will find that Taylorite passes your severest tests with flying colors. Write for Data Sheet 2-0 and samples today. Taylor Fibre Co., Norristown 47, Pa.

KICK-BACK PLATES of Taylorite give good pin action, prevent pin damage

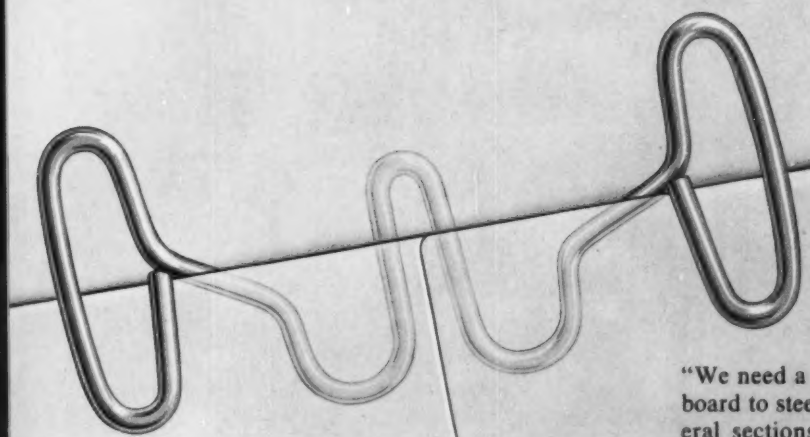


Circle 486 on Page 19

Circle 487 on Page 19→

KEYSTONE WIRE... DUDEK & BOCK

turn an idea into a reality



"We need a clip that will securely fasten gypsum board to steel upright studs—or join and hold several sections of board in perfect alignment for plastering. Here's what it must look like."

This is the challenge. Designers at Dudek & Bock, Chicago, Illinois, roll up their shirt sleeves. They analyze wire requirements: tensile, uniformity. Length of run—a long one. Delivery—soon.

What wire fits these requirements? Keystone Silver Brite Galvanized high tensile wire is first choice. They know from experience they can depend on Keystone wire to perform exactly as calculated—order after order—run after run. By standardizing on Keystone wire for the majority of their needs, Dudek & Bock simplify quality control and manufacturing problems. They regularly use a wide selection of Keystone wire to meet their forming and spring requirements—this includes low and high carbon wire, brite and galvanized.

Result: Another fastener problem solved with wire . . . delivery on schedule of this gypsum board clip and thousands of other items . . . and maximum customer satisfaction.

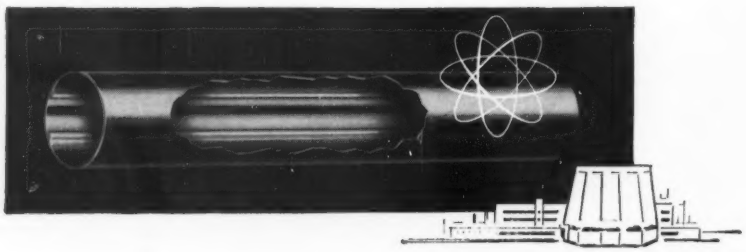
Perhaps creative imagination and Keystone wire can help you build your products faster, better, at lower cost. A Keystone cold heading or wire forming specialist is available to help you.

Keystone Steel & Wire Company, Peoria, Illinois

KEYSTONE

WIRE FOR INDUSTRY

When tubular parts must meet unusual "specs"—



Check ROCKRITE® SPECIAL-FORMED TUBING

How *really* impossible are your tubular part requirements? For example, a nine-foot casing for delicate oil well test instruments demands I.D. straightness no more than .003 ins/foot, minimum yield of 120,000 psi and exceptional tolerance—all in 3⅝-inch tubing. ROCKRITE delivers the solution—just as it does regularly (in another application) for nuclear reactors. Here, lengths up to 60 feet, in zirconium, are produced with defect-free I.D. and O.D. surfaces. Other special tubing shapes easily achieved with the ROCKRITE Process include:

RIBBED TUBING—*illustrates ability to work in rare metals and non-symmetrical configurations and eliminate machining and waste of expensive stock.*

STEP-TAPERED TUBING—*for structural members of wings and other highly stressed aircraft parts. Guaranteed defect-free quality.*

SAE 52100 STEEL—*close tolerance and improved machinability for high speed production of anti-friction bearing raceways.*

SPECIAL BORE TUBING—*bore shapes available: square, triangular and hexagonal, with very slight radius corners.*

Full details, of critical interest in solving your tubular parts problems, in Technical Bulletin SP-1. Write for your copy today—no obligation.

TUBE REDUCING CORPORATION

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ROCKRITE® TUBING

9-512

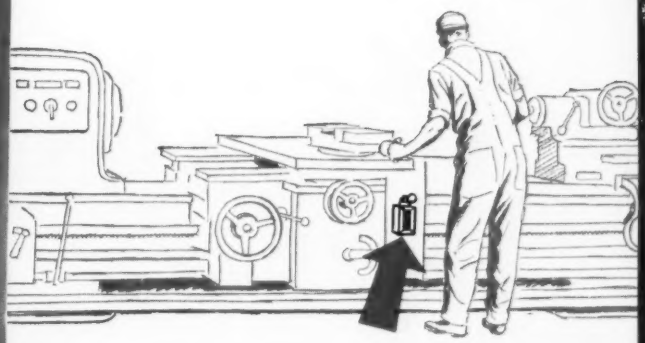
Circle 488 on Page 19

Circle 489 on Page 19→

ALLEN-BRADLEY

REVERSING DRUM SWITCHES

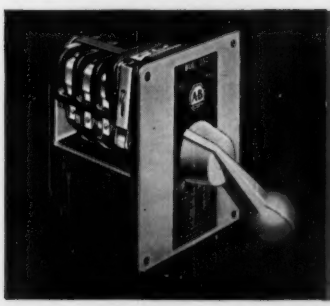
BULLETIN 350
Style A wrap-around cover is removed to show the readily accessible front wiring terminals. Max rating: 2 hp.



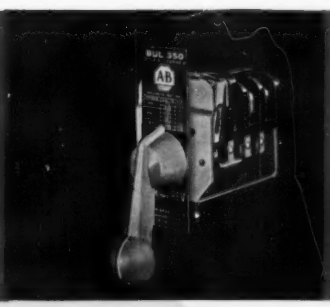
...styled to match the most modern production machines!

Inside and out—this Allen-Bradley drum switch is *all* new. Its trim, modern lines and attractive die-cast aluminum handle will give your production machines "up-to-the-minute" styling.

But there is more than beauty to this new switch. The rugged switch mechanism is a self-contained unit—independent of the enclosure. Misalignment and binding *cannot* occur. The base mounts directly on machine surfaces—without using spacers. And with the wrap-around cover removed, terminal screws are exposed for fast wiring—from the front. Changeover from momentary to maintained contact operation can be made in seconds. Investigate this new "leader" in its field. Send for Publication 6091.



OILTIGHT CAVITY MOUNTING
A-B Style AF reversing switches can be furnished with sealed shaft and rubber-gasketed, oiltight cover for cavity mounting in a machine base.



PANEL MOUNTING
The new Style A switches can be furnished for mounting directly on panels. Nameplate which gives ratings is also included with each switch.

ALLEN-BRADLEY

Quality Motor Control

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

5-60-R

ALLEN-BRADLEY
Solenoid Starters give

MORE MILLIONS OF TROUBLE FREE OPERATIONS

. . . and for good reasons

• ONE MOVING PART

With this simple solenoid design, there's virtually nothing to go wrong—all trouble-causing bearings, pivots, and flexible jumpers have been eliminated.

• DOUBLE BREAK, SILVER ALLOY CONTACTS

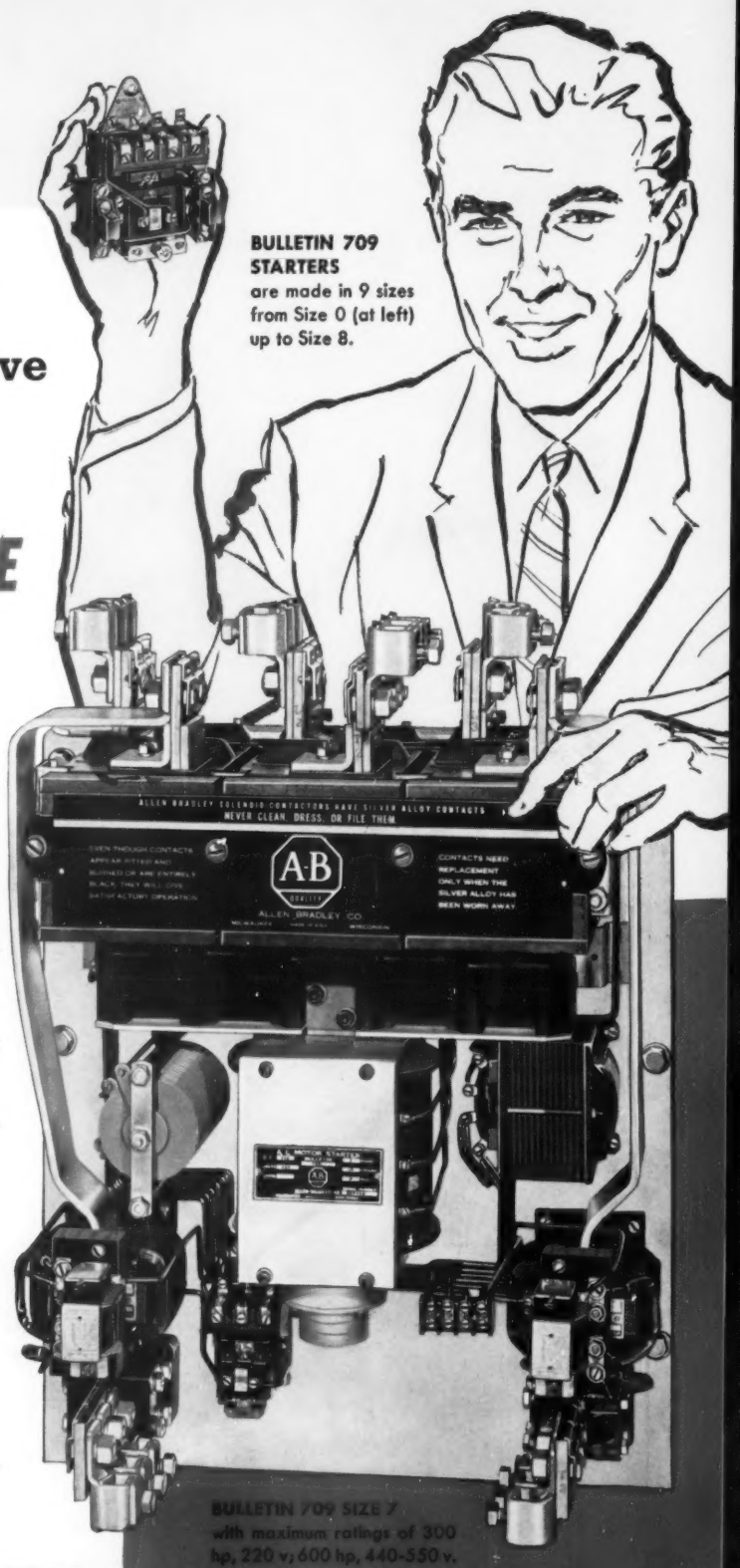
Allen-Bradley silver alloy contacts never require maintenance. They are always in perfect operating condition . . . and remain so until completely worn away.

• SIMPLE UP-AND-DOWN MOTION

The virtually frictionless, straight line vertical motion provides uniform contact pressure at all times—and assures consistent, rapid operation of the contactor.

• RELIABLE OVERLOAD PROTECTION

All A-B starters are equipped with two permanently accurate and reliable overload relays that protect motors against "burnouts." Three overload relays can be furnished.


ALLEN BRADLEY SOLENOID CONTACTORS HAVE SILVER ALLOY CONTACTS
NEVER CLEAN, DRESS, OR FILE THEM
CONTACTS NEED REPLACEMENT ONLY WHEN THE SILVER ALLOY HAS BEEN WORN AWAY
ALLEN-BRADLEY CO.

BULLETIN 709 STARTERS are made in 9 sizes from Size 0 (at left) up to Size 8.

BULLETIN 709 SIZE 7 with maximum ratings of 300 hp, 220 v; 600 hp, 440-550 v.

ALLEN-BRADLEY
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Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

QUALITY MOTOR CONTROL

3-60-2

MACHINE DESIGN
February 18, 1960

The Jump on Competition

WHEN to take the wraps off a new development is a touchy problem in both military and industrial product design. A recent experience here illustrates the sort of answer that is sometimes encountered.

Along with other publications, MACHINE DESIGN received a news release describing a consumer product with interesting new mechanical features. These features give the new model unique characteristics which greatly enhance its position in a highly competitive market.

We believe our readers would find the new mechanism of considerable interest. Besides the few others designing a similar product, the many who are in other fields could benefit from the interchange of ideas. Our request for design information and illustrations was flatly rejected. The reason? Fear of giving away information to a possible competitor.

Such a policy ignores the obvious fact that the new model can be purchased in a store for a couple of hundred dollars, could be dissected and analyzed in a few hours, copied and put into production in a matter of weeks. The Japanese may be doing so right now.

By refusing information for publication, the company hasn't really preserved a competitive edge. In fact, it has lost an opportunity to acquire prestige through having its name associated with the initial publication of a clever design idea. Imitators can come along any time now and take undeserved credit.

Best remedy for such insecurity is to have, in the works and quite properly under wraps, so many new developments that competition can never really catch up.

Colin Carmichael
EDITOR

Mobility

Mechanical mobility . . . Mechanical impedance . . . bywords for two of the most promising techniques of vibration analysis developed in recent years. Interchangeable in use, these companion techniques provide a simple, straightforward basis for solving problems not easily handled by other methods. But just what are mobility and impedance, and how are they used? Part of the answer is given in two earlier articles (December 10 and December 24, 1959) on fundamental concepts of the mobility approach. Other basic principles as well as details of more advanced methods of dynamic analysis will be presented in this series of articles.

Mobility and impedance concepts are summarized in this first article. Succeeding articles will show how these concepts are used to predict steady-state dynamic response of different types of linear mechanical systems. Future topics: Single and two degree of freedom systems . . . lumped multiple-mass systems . . . combination systems . . . beams and frames.

AUSTIN H. CHURCH
Chairman, Mechanical Engineering Dept.
College of Engineering
New York University
New York, N. Y.

Simplified Vibration Analysis 1

and Impedance Concepts

VIBRATING mechanical systems are analogous to equivalent electrical circuits. In fact, two forms of these analogies may be made.

In the more common form, a mass is equivalent to an inductance and a spring is equivalent to a capacitor. This "mass-inductance" analogy is based on Kirchoff's Second Law for electrical circuits: The sum of the potential drops around any loop of a circuit is zero.[1,2,3,4]

In the second analogy, a mass is equivalent to a capacitor and a spring is equivalent to an inductance. This "mass-capacitance" analogy is based on Kirchoff's First Law: The sum of the currents flowing to any point in a circuit is zero.[3,5,6]

Both analogies, which are summarized in Table 1, are based on the similarity of the differential equations for mechanical and electrical systems. The mobility method is based on the mass-capacitance analogy and will be discussed later in more detail.

When the equivalent mechanical circuit is sketched, either electrical symbols, Table 1, or mechanical symbols, Fig. 1, may be used. For uniformity, mechanical symbols will be used here.

System Response

Throughout these articles, response to a single harmonic force is considered. Any periodic force or torque can be analyzed by means of a Fourier series of a number of harmonic forces. Response can then be found for each harmonic term of this series. The separate responses can then be recombined to obtain a resultant periodic response. This procedure greatly widens the scope of the mobility method.

Systems analyzed here are considered to be linear at all times. That is, motion response at any point is always proportional to the magnitude of the impressed harmonic force.

Mobility is defined as the ratio of the maximum value of the response of a point in a system produced by a harmonic force to the maximum value

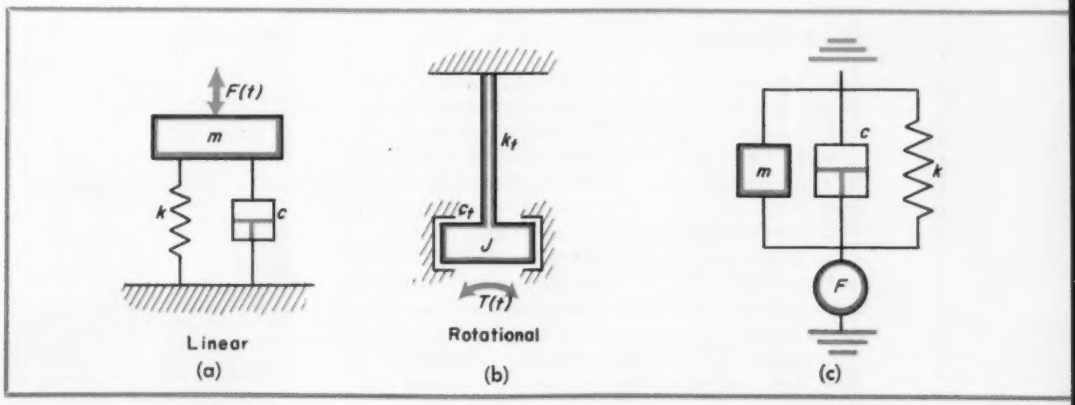


Fig. 1—Typical diagrams using mechanical symbols. Shown schematically are equivalent linear (*a*) and rotational (*b*) mechanical systems. Circuit diagram for mass-capacitance analogy is shown at *c*. Equivalent circuit diagrams using electrical symbols are given in Table 1 for both mass-inductance and mass-capacitance analogies.

of that force, F_o. If the maximum value of harmonic response is R_o, mobility $M = R_o/F_o$. Impedance is the inverse of mobility, or $Z = F_o/R_o$ for a single-degree-of-freedom system.

Mobility may be considered as response per unit force, or as a measure of the readiness of a point to respond to a harmonic force. Impedance may be thought of as the force required to produce a unit response, or as a measure of the resistance of a point to response.

The form of motion response to be used depends on the type of problem and the impressed frequency. For low frequencies, stress is proportional to displacement which can be measured easily. Hence, displacement mobility M_D, which is the ratio of maximum displacement to maximum impressed force, or x_o/F_o, may be used. This ratio is also known as "receptance" or "mechanical admittance."

Nomenclature

a = Acceleration, in. per sec per sec
c = Viscous damping factor, lb-sec per in.
e = Natural logarithm base
F = Force, lb
J = Mass moment of inertia, in.-lb-sec^2
j = Imaginary operator $= (-1)^{½}$
k = Spring gradient or rate, lb per in.
M = Mobility
M_A = Acceleration mobility, in. per lb-sec^2
M_D = Displacement mobility, in. per lb
M_V = Velocity mobility, in. per lb-sec
m = Mass, lb-sec^2 per in.
R = Response
T = Torque or moment, lb-in.
t = Time, sec
v = Velocity, in. per sec
x = Linear displacement, in.
Z = Impedance
Z_A = Acceleration impedance, lb-sec^2 per in.
Z_D = Displacement impedance, lb per in.
Z_V = Velocity impedance, lb-sec per in.
θ = Angular displacement, or slope, rad
ψ = Phase angle between force and velocity vectors, degrees or rad
ω = Circular or angular frequency, rad per sec

Subscripts

C = Combined
d = Damper
m = Mass
n = Natural or resonant
o = Amplitude or vector length; characteristic
s = Spring

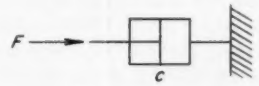
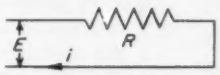
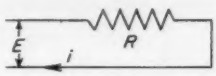
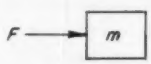
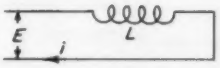
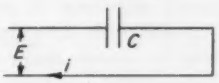
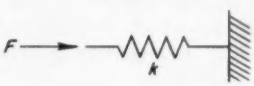
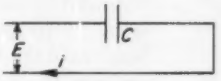
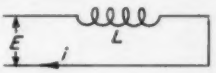
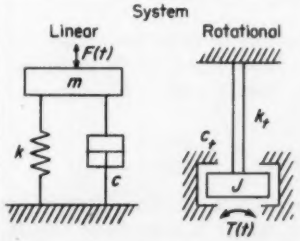
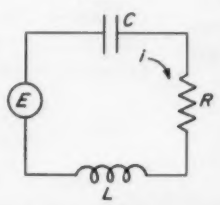
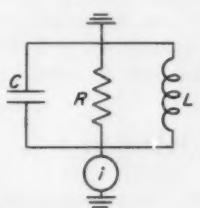
About the Author . . .

An eminent engineer and educator, Austin Church speaks as a recognized authority on vibration analysis and machine dynamics. His most recent book, *Mechanical Vibrations,* published in 1957, is widely used as a fundamental text. Other books include *Centrifugal Pumps and Blowers* (1944) and the fifth edition of Guillet's *Kinematics of Machines* (1950).

He joined NYU as an assistant professor in 1940 and was made chairman of the Mechanical Engineering Dept. in 1946. His varied career also includes experience as a design engineer and consultant.

A registered Professional Engineer (Mechanical) in New York, he holds degrees from Cornell and NYU. In addition to his books, he is the author of a number of magazine articles and papers. The present series of articles is a result of studies carried out at GE's General Engineering Laboratory while on leave of absence from NYU.

Table 1—Mechanical-Electrical Analogies

Mechanical			Electrical Equivalents			
			Mass-Inductance Analogy		Mass-Capacitance Analogy	
	Linear	Rotational				
Force or torque	F	T	Voltage	E	Current	i
Damping	c	c_t	Resistance	R	Conductance	$1/R$
Mass or inertia	m	J	Inductance	L	Capacitance	C
Compliance	$1/k$	$1/k$	Capacitance	C	Inductance	L
Velocity	v	$\dot{\theta}$	Current	i	Voltage	E
Displacement	x	θ	Charge	q		$\int E dt$
Damping			Resistance		Resistance	
						
$F = cv = c\frac{dx}{dt}$			$E = Ri = R\frac{dq}{dt}$		$i = E/R$	
Power $= Fv = cv^2$			Power $= Ei = Ri^2 = R\left(\frac{dq}{dt}\right)^2$		Power $= Ei = E^2/R$	
Mass			Inductance		Capacitance	
						
$F = m\frac{dv}{dt} = m\frac{d^2x}{dt^2}$			$E = L\frac{di}{dt} = L\frac{d^2q}{dt^2}$		$i = C\frac{dE}{dt}$	
Kinetic Energy $= \frac{1}{2}mv^2$			Energy $= \frac{1}{2}Li^2$		Energy $= \frac{1}{2}CE^2$	
Spring			Capacitance		Inductance	
						
$F = kx = k\int v dt$			$E = (1/C)q = \frac{1}{C}\int i dt$		$i = (1/L)\int E dt$	
Potential Energy $= \frac{1}{2}F^2/k$			Energy $= \frac{1}{2}CE^2$		Energy $= \frac{1}{2}Li^2$	
System			Circuit		Circuit	
						
At point: $\Sigma F = 0$; $\Sigma T = 0$			For loop: $\Sigma(\Delta E) = 0$		At point: $\Sigma i = 0$	
$m\frac{dv}{dt} + cv + k\int v dt = F(t)$			$L\frac{di}{dt} + Ri + \frac{1}{C}\int i dt = E(t)$		$C\frac{dE}{dt} + \frac{E}{R} + \frac{1}{L}\int E dt = i(t)$	
$m\frac{d^2x}{dt^2} + c\frac{dx}{dt} + kx = F(t)$			$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = E(t)$		$C\frac{d^2E}{dt^2} + \frac{1}{R}\frac{dE}{dt} + \frac{E}{L} = \frac{di(t)}{dt}$	

Current emphasis is on velocity response.[7] For this case, velocity mobility, $M_V = v_o/F_o$, is used. Velocity mobility is particularly applicable for higher frequencies of vibration where stress is more nearly a function of the velocity of response, or when impact loading may occur, since impact is a function of mass and velocity. When inertia loadings predominate, the use of acceleration mobility, $M_A = a_o/F_o$, may be desirable.

Conversion of one form of motion response to another is accomplished by applying the impressed circular frequency term, ω. If only the real portion of motion is considered, conversion relationships are:

$$x = x_o \cos \omega t \tag{1}$$

$$v = \frac{dx}{dt} = -x_o \omega \sin \omega t = -v_o \sin \omega t \tag{2}$$

$$a = \frac{dv}{dt} = -x_o \omega^2 \cos \omega t = -v_o \omega \cos \omega t \tag{3}$$

Forces and motions of systems having damping are more conveniently expressed in terms of complex numbers, which generally simplify calculations. Then, both real and imaginary terms must be considered, and the conversion equations become:

$$x = x_o e^{j\omega t} \tag{4}$$

$$v = \frac{dx}{dt} = j\omega x_o e^{j\omega t} = v_o e^{j\omega t} \tag{5}$$

$$a = \frac{dv}{dt} = j^2 \omega^2 x_o e^{j\omega t} = -\omega^2 x_o e^{j\omega t} = j v_o \omega e^{j\omega t} \tag{6}$$

where

$$e^{j\omega t} = \cos \omega t + j \sin \omega t \tag{7}$$

Two general types of response are important. One is "driving-point response," in which response is found at the point where the excitation force acts. The other is "transfer response," which is response at one point when excitation is applied at another.

Both rectilinear and torsional systems are considered here. The procedures and discussions apply equally well to either type of system.

Definitions and Principles

Initially, mobility and impedance will be considered on a velocity basis. Later, these principles will be extended to include displacement and acceleration responses.

When damping is present in a system, forces are no longer collinear, and a phase angle becomes evident. Mobility is then a complex number. When a motion vector with complex numbers is differentiated, the vector is multiplied by the product, $j\omega$, as demonstrated by Equations 4, 5, and 6. This operation multiplies the length of the vector by ω, and the j term rotates the vector forward (in the direction of rotation) 90 degrees. From Equations 4, 5, and 6, then,

$$x = \frac{v}{j\omega} = \frac{a}{j^2\omega^2} = -\frac{a}{\omega^2} \tag{8}$$

By definition, velocity mobility M_V is the ratio v_o/F_o, which generally involves a phase angle, ψ. Thus, if excitation is $F = F_o \cos \omega t$ and response is $v = v_o \cos(\omega t + \psi)$, then $M_V = v_o/(F_o \angle \psi)$, where M_V is a complex number whose modulus, or absolute value, is v_o/F_o and whose argument, or phase angle, ψ, is the angle by which v_o leads F_o.

Mobility may be found for each of the various types of components. Mobility of a spring or dashpot is determined across the component. Thus, mobility is the motion of one end of the component relative to the other end divided by the maximum excitation force acting across or through the component. Mobility of mass is the ratio of its maximum sinusoidal response relative to inertial space to the maximum sinusoidal excitation that causes the response.

Velocity Response of Components: Velocity mobility of springs, masses, and dampers can be readily determined by straightforward procedures.

SPRINGS: Displacement of a spring is $x = F/k$. From Equation 8, maximum velocity is $v_o = j\omega x_o$, which may also be written as $v_o = j\omega F_o/k$. Hence,

$$M_{Vs} = \frac{v_o}{F_o} = \frac{j\omega F_o}{k F_o} = \frac{j\omega}{k} \tag{9}$$

A spring does not dissipate energy but merely stores it in potential form, which is recoverable. Note that the term for M_{Vs} is imaginary because it contains j.

Since impedance of an element is the reciprocal of mobility, or F_o/v_o,

$$Z_{Vs} = \frac{k}{j\omega} = -\frac{jk}{\omega}$$

MASSES: The relationship between force and motion is $F = ma$. But from Equation 8, $a = j\omega v$. Hence, $v = a/(j\omega) = F/(mj\omega)$, and

$$M_{Vm} = \frac{F_o}{m j \omega F_o} = \frac{1}{j\omega m} = -\frac{j}{m\omega} \tag{10}$$

A mass in motion does not dissipate energy but stores it in kinetic form, which is recoverable. Again, note that the velocity mobility is imaginary because of the j term.

Velocity impedance of the mass then becomes

$$Z_{Vm} = \frac{m\omega}{-j} = jm\omega$$

DAMPERS: If damping is viscous, $v = F/c$, and

$$M_{Vd} = \frac{F_o}{c F_o} = \frac{1}{c} \tag{11}$$

A damper dissipates energy in the form of heat which is not recoverable. Because it does not con-

Table 2—Typical Mobility Diagrams for Mass-Capacitance Analogy

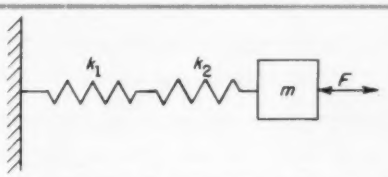
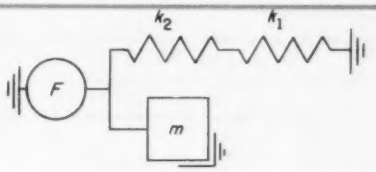
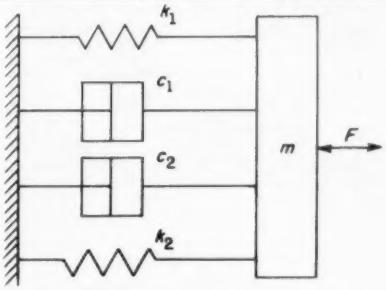
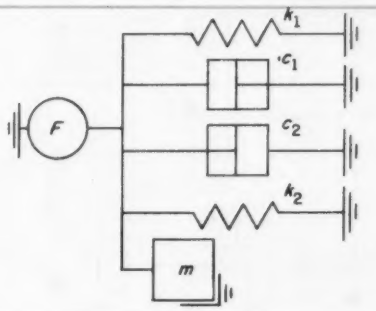
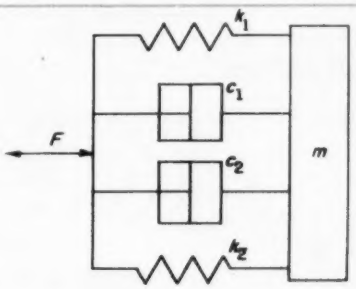
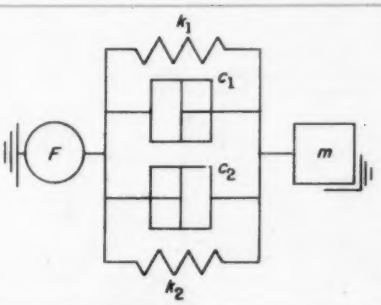
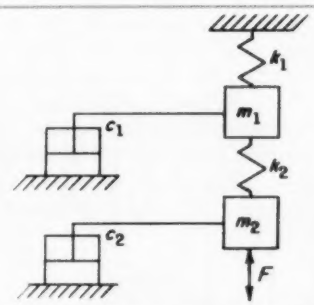
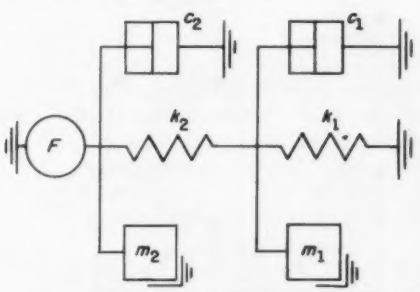
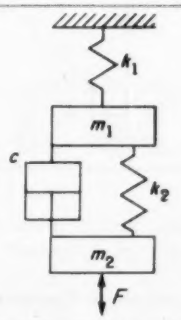
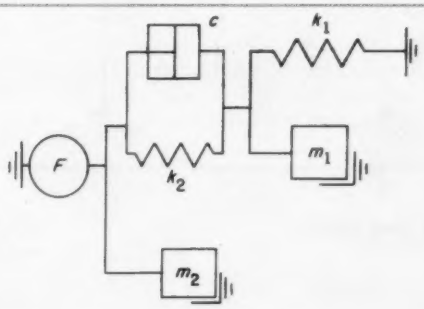
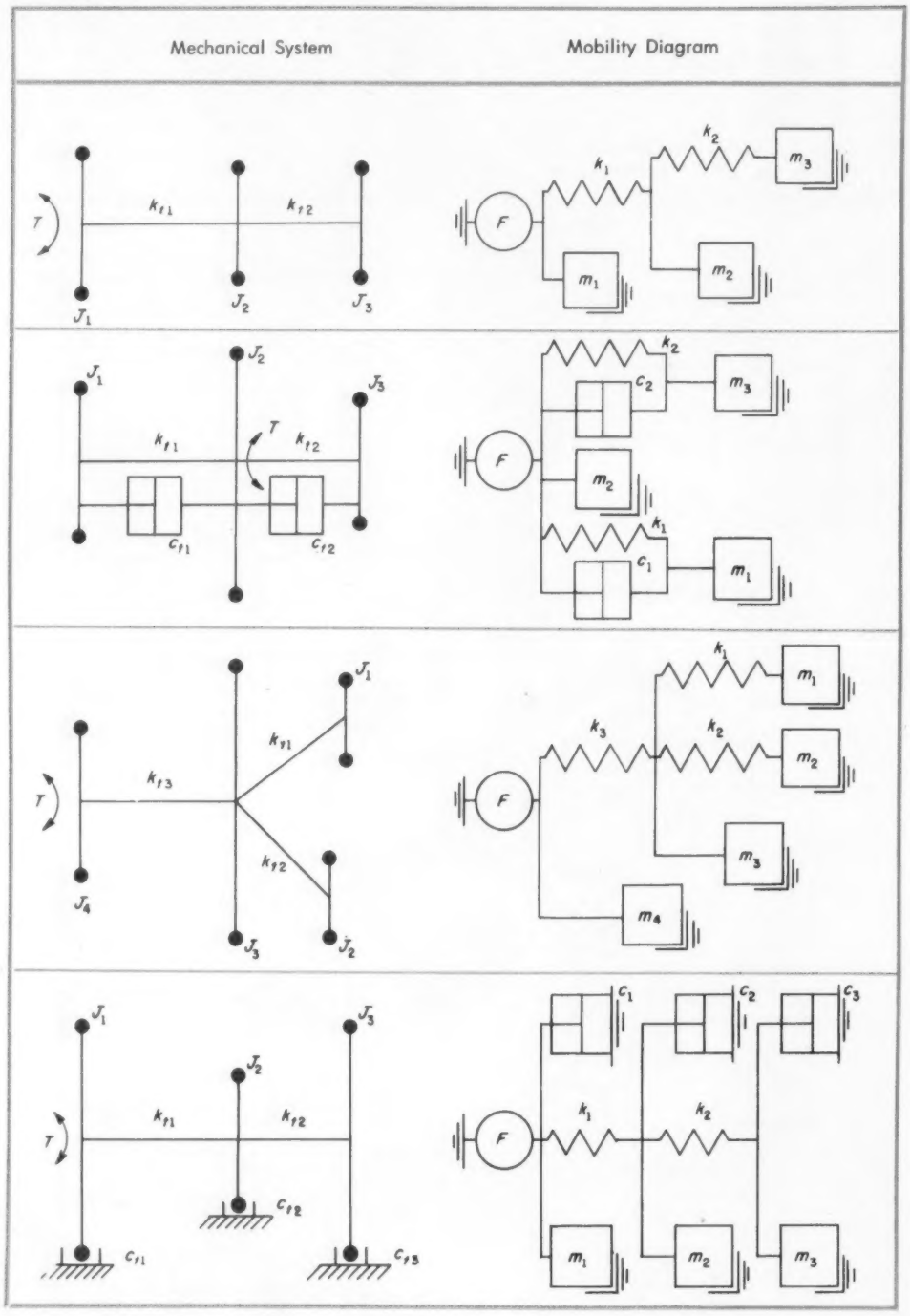
Mechanical System	Mobility Diagram
	
	
	
	
	

Table 2 (continued)



tain j, this mobility term is real.

Impedance is

$$Z_{Yd} = c$$

Thus, velocity mobilities are complex numbers in which imaginary terms represent energy storage and real terms represent energy dissipation.

Displacement Response of Components: As mentioned previously, response to excitation may be

analyzed in terms of displacement rather than velocity. The ratio of maximum displacement to maximum value of the impressed force is common and will be called "displacement mobility," M_D. Equations for displacement mobility can be found by a process similar to that used for velocity mobility.

For a spring, $x = F/k$, so,

$$M_{Ds} = \frac{x_o}{F_o} = \frac{F_o}{kF_o} = \frac{1}{k} \qquad (12)$$

For a mass, $F = ma$. But from Equation 8, $a = -\omega^2 x$. Therefore, $F_o = -m\omega^2 x_o$, or $x_o = F_o/(-m\omega^2 v)$, and

$$M_{Dm} = \frac{x_o}{F_o} = \frac{F_o}{-m\omega^2 F_o} = -\frac{1}{m\omega^2} \qquad (13)$$

For a damper, $v = F/c$. But $v_o = j\omega x_o$, or $x_o = F_o/(cj\omega)$. Then,

$$M_{Dd} = \frac{x_o}{F_o} = \frac{F_o}{cj\omega F_o} = -\frac{j}{c\omega} \qquad (14)$$

In these expressions for response, the imaginary part represents dissipation of energy while the real part represents energy storage. These results are just the reverse of those obtained for velocity mobilities.

Impedance forms of Equations 12, 13, and 14 are:

$$Z_{Ds} = k$$

$$Z_{Dm} = -m\omega^2$$

$$Z_{Dd} = cj\omega$$

Acceleration Response of Components: The third possible method of calculating response is to find the ratio of maximum acceleration to maximum applied force. This method is designated "acceleration mobility," M_A.

From Equation 8, $a_o = j^2\omega^2 x_o = -\omega^2 x_o$, or $a_o = j\omega v_o$. With these relationships, equations for acceleration mobility of the components become:

$$M_{As} = \frac{a_o}{F_o} = -\frac{\omega^2 x_o}{kx_o} = -\frac{\omega^2}{k} \qquad (15)$$

$$M_{Am} = \frac{a_o}{F_o} = \frac{a_o}{ma_o} = \frac{1}{m} \qquad (16)$$

$$M_{Ad} = \frac{a_o}{F_o} = \frac{j\omega v_o}{cv_o} = \frac{j\omega}{c} \qquad (17)$$

In terms of acceleration impedance,

$$Z_{As} = -\frac{k}{\omega^2}$$

$$Z_{Am} = m$$

$$Z_{Ad} = \frac{c}{j\omega} = -\frac{cj}{\omega}$$

In these expressions for acceleration response, the imaginary part represents dissipation of energy while the real part is storage of energy. Hence, acceleration response is similar, in this respect, to displacement response.

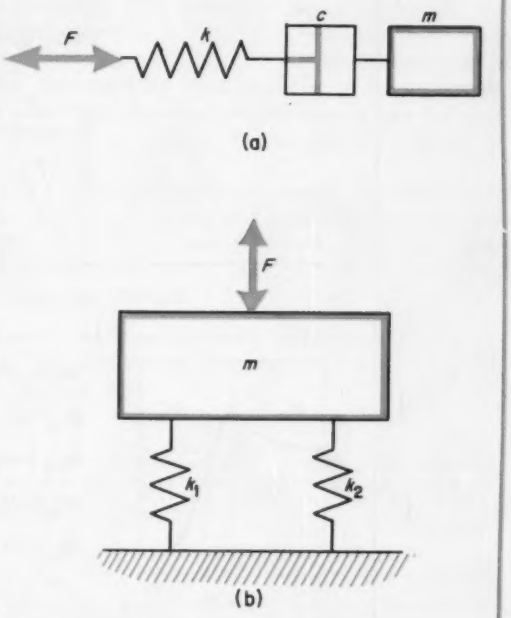


Fig. 2—Components of vibrating mechanical system in, *a*, series combination and, *b*, parallel combination.

Combinations of Components: A vibrating mechanical system is usually composed of a number of components grouped in two types of combinations: Series and parallel.

A series combination, Fig. 2*a*, has the same force acting through several components at any instant. Response is the sum of the individual responses of the components. Then, combined mobility, M_C, is

$$M_C = \frac{R_C}{F_C} = \frac{R_1}{F_C} + \frac{R_2}{F_C} + \ldots = M_1 + M_2 + \ldots \qquad (18)$$

A parallel combination, Fig. 2*b*, has the same response for all components. The force acting on the combination equals the sum of the forces acting through the individual components, or

$$M_C = \frac{R_C}{F_C} = \frac{R_C}{F_1 + F_2 + \ldots} = \frac{1}{\frac{1}{M_1} + \frac{1}{M_2} + \ldots} \qquad (19)$$

This equation can be simplified by using im-

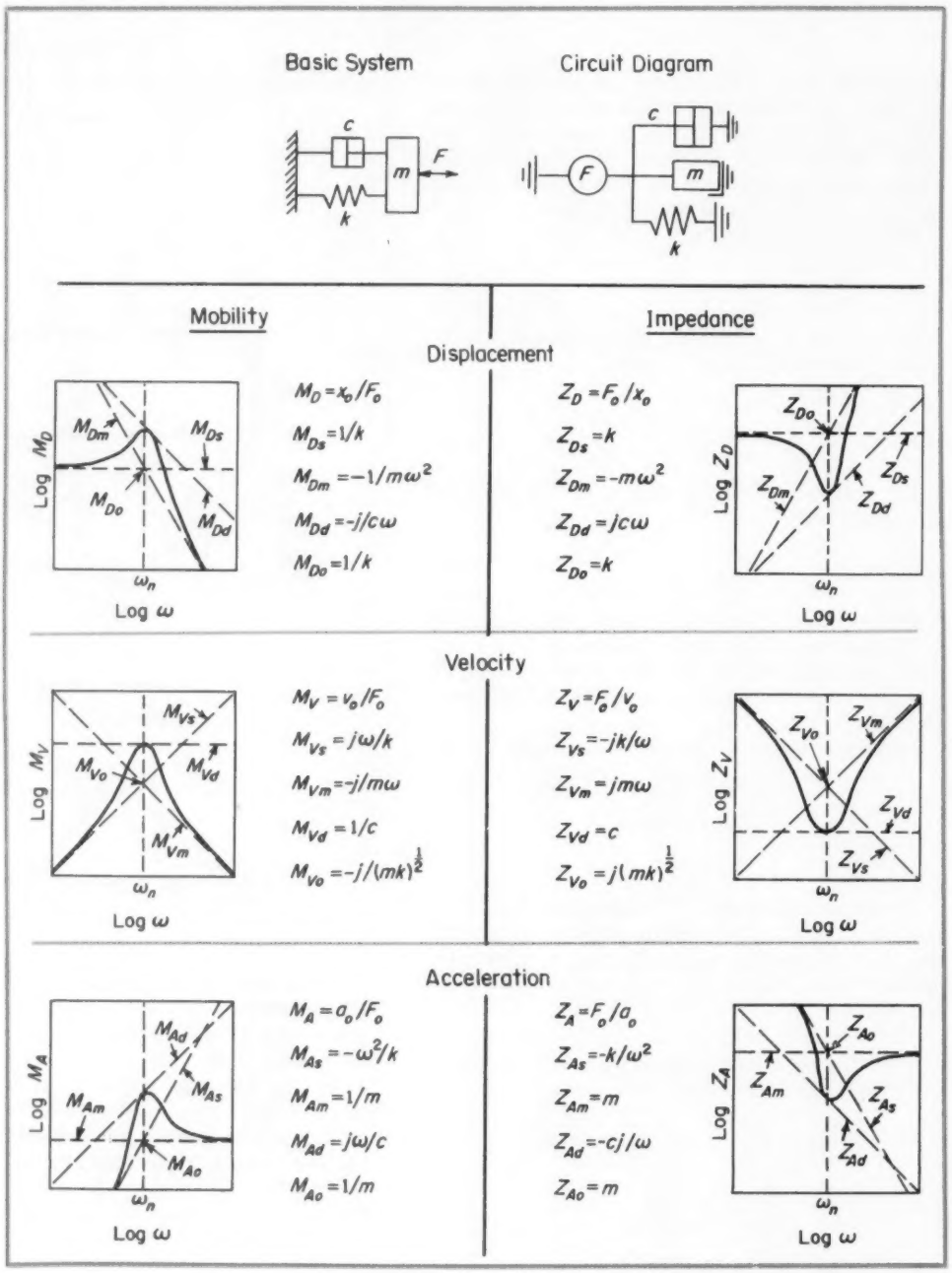


Fig. 3—Mobility and impedance relationships for a single-degree-of-freedom system.

pedance relationships, which give

$$M_C = \frac{1}{Z_C} = \frac{1}{Z_1 + Z_2 + \ldots .} \qquad (20)$$

where

$$Z_C = Z_1 + Z_2 + \ldots . \qquad (21)$$

Schematic Diagrams: Before mobility or impedance of a point in an elastic system consisting of a number of components is calculated, the suggested procedure is to first draw a schematic or dynamic circuit diagram based on the mass-capacitance analogy. This diagram will show whether components are

combined in series or parallel. Also, diagrams based on this analogy follow the principles outlined in the preceding discussion on combinations of components. The value and use of these diagrams will become more evident in the discussion to follow.

Components that are attached to a fixed member are shown "grounded." The ground connection also applies to mass components that develop inertia forces which have magnitudes proportional to the acceleration with respect to inertial space of the mass; that is, relative to ground or a "fixed" link. Exciting force is usually located at the left end of the diagram with components to the right in combinations as just outlined.

Table 2 shows several schematic mobility diagrams.[8] As noted previously, mechanical symbols are used rather than analogous electrical symbols. In these diagrams, the point of excitation determines, in part, if the combinations of components are in parallel or series. In the event that vibration is "free," the impressed force is omitted from the diagram.

Diagrams in Table 2 apply equally well to rectilinear or torsional elastic systems. In this regard, generalized symbols are used. Thus, F designates either a force, F, or a torque, T; m a mass or a mass moment of inertia, J; k a rectilinear or torsional spring rate; etc.

Mobility Plots: Results obtained from the analysis of velocity, acceleration, and displacement responses of components are summarized in Fig. 3. Component mobilities are plotted as straight lines on log-log scales for a single-degree-of-freedom system in which components all act in parallel.

Response of each component is plotted as a straight line with a slope corresponding to the exponent of the ω term. The solid curve represents the resultant response of mass due to the action of various components. The procedure for obtaining this resultant response will be developed in a later article on single-degree-of-freedom systems. Comparison of the accompanying equations, Fig. 3, points out the relationships developed earlier; that is, for the various components, $M_V = j\omega M_D$, and $M_A = j\omega M_V = -\omega^2 M_D$.

Of course, other arrangements of the components in various series and parallel combinations are possible. Such arrangements would affect the shape of the resultant curve and also will be considered in later articles.

Next article in this series will discuss three methods for determining response in single-degree-of-freedom systems.

ACKNOWLEDGMENT

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Tips and Techniques

Juncture Pipe Stresses

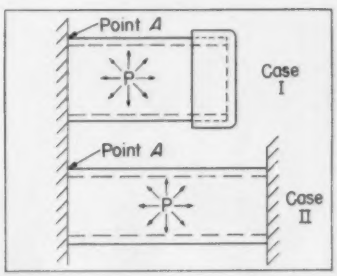
The longitudinal stress at the juncture of a pipe and a wall is required of some design problems. The maximum longitudinal stress for the two principal cases occurs at point A. For case I (capped end) this stress is given by

$$S_{max} = \left[\frac{1}{2} + \left(1 - \frac{\nu}{2} \sqrt{\frac{3}{(1-\nu)^2}} \right) \right] \frac{PR}{T}$$

For case II the stress is given by

$$S_{max} = \sqrt{\frac{3}{(1-\nu)^2}} \left(\frac{PR}{T} \right)$$

Where S = stress, psi; ν = Poisson's ratio; P = pressure, psi; R = radius, in.; and T = thickness, in.—EDWARD N. NELSON SR., *analytical engineer, Solar Aircraft Co., San Diego, Calif.*



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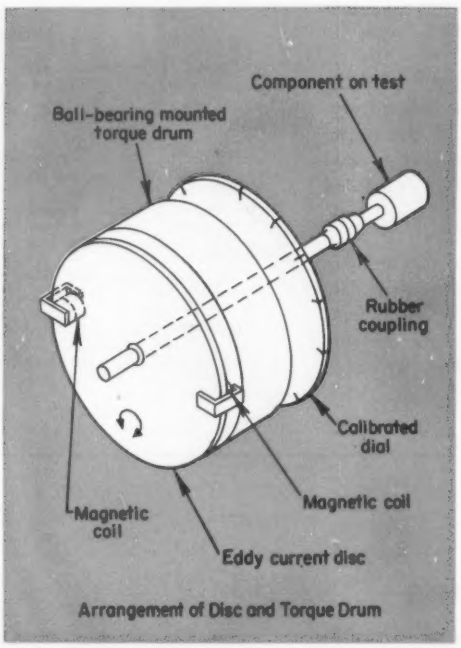
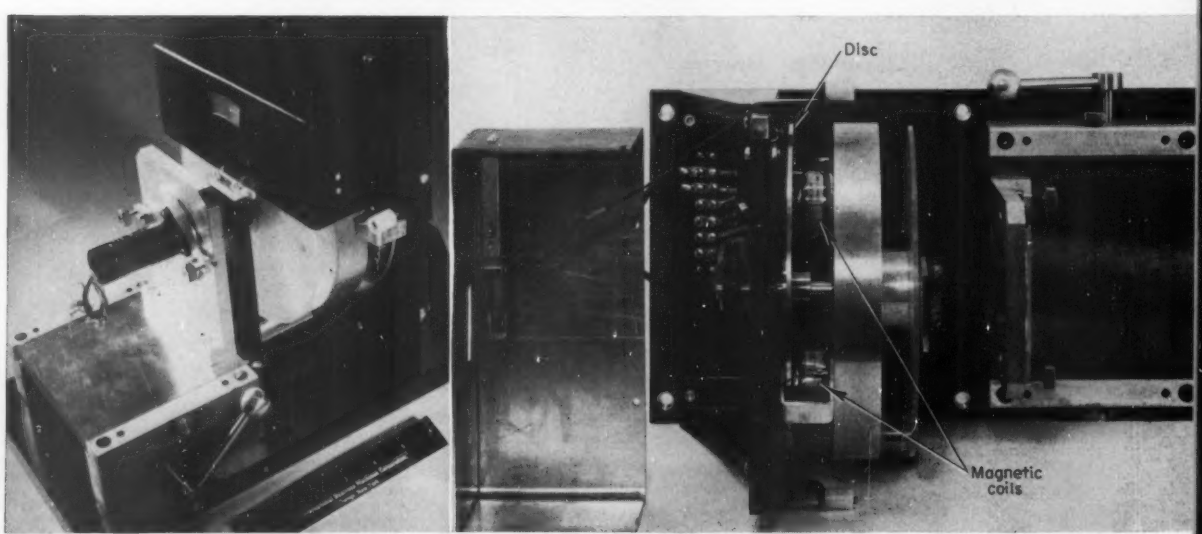
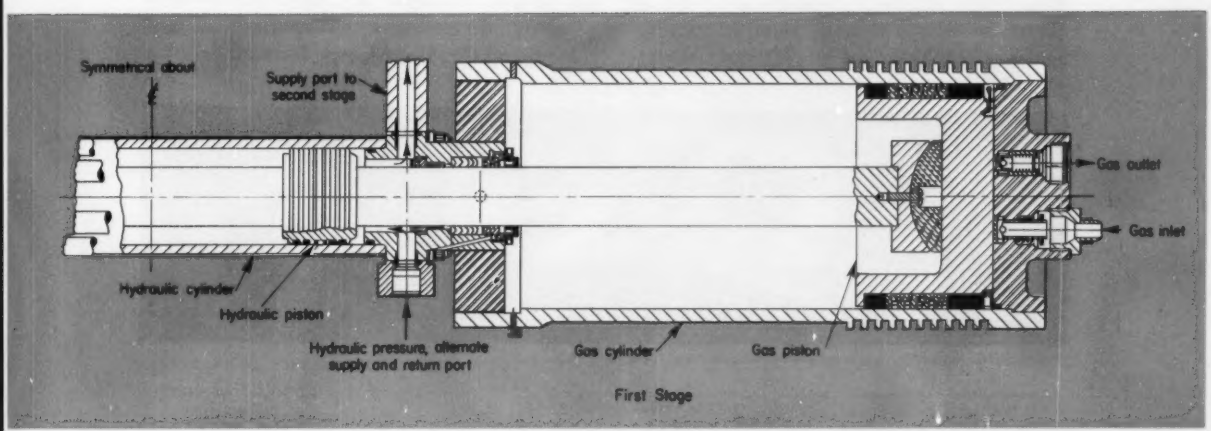
scanning the field for *ideas*

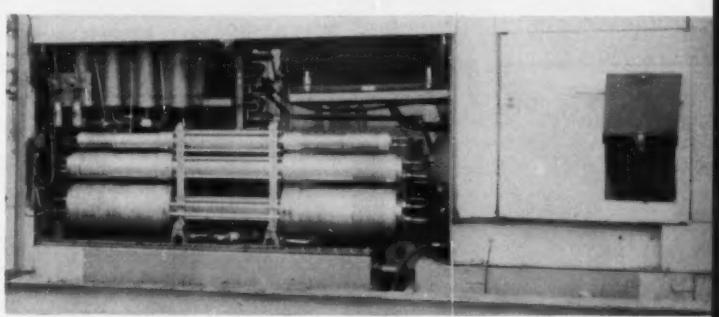


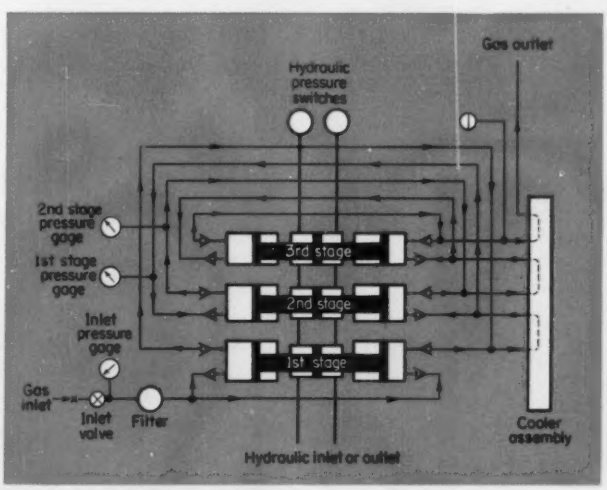
Arrangement of Disc and Torque Drum

Aluminum eddy-current disc permits high-speed operation of instrument dynamometer with minimum inertia effects. The aluminum disc, which is a good conductor but nonmagnetic, rotates in a magnetic field provided by two magnetic coils. Eddy currents generated by the disc create another magnetic field, producing a force which opposes the force from the main field. This action simulates the resistance load that is applied to a shaft component under test. Light weight of the aluminum minimizes the inertial resistance of the disc at high speed, reducing the error in dynamic torque measurements. Reported by B. A. Kohler, aluminum disc employed in a dynamometer developed by IBM Corp., Owego, New York.



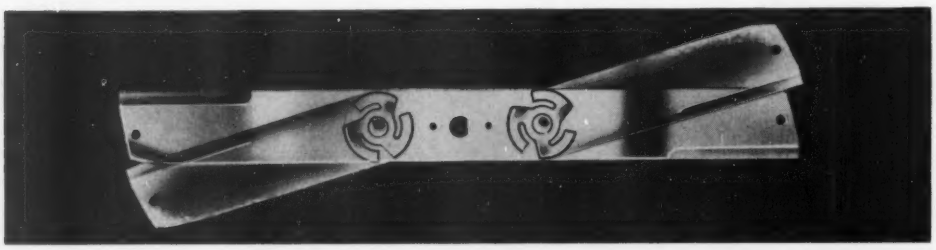




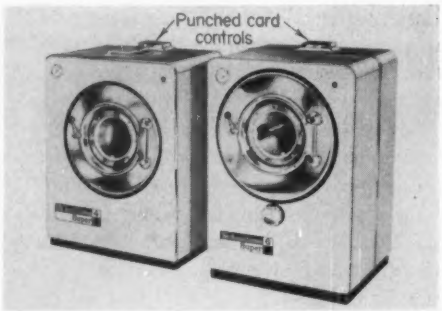


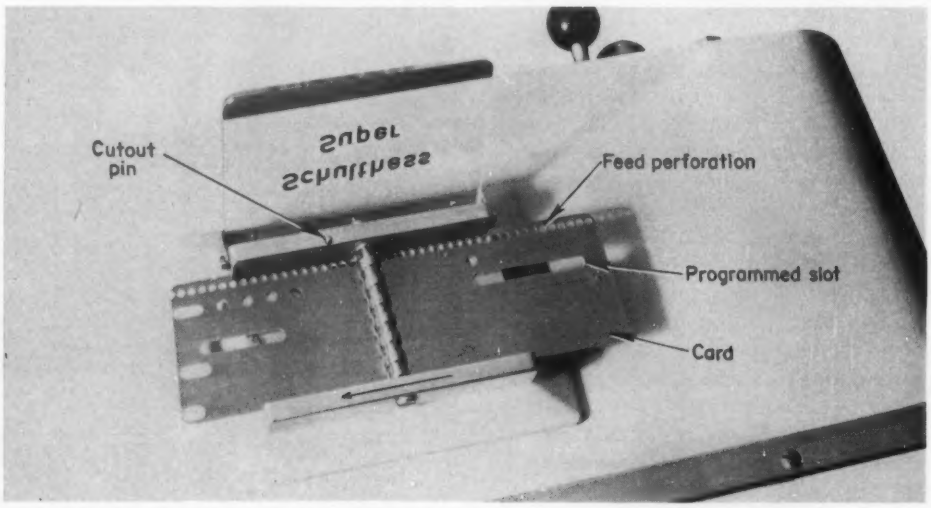
Hydraulic "drive" cylinders automatically compensate for inlet pressure changes in a multiple stage gas compression system. The piston rods of the centrally located hydraulic cylinders extend some distance through the cylinder end caps, each of which is machined to accept a gas cylinder. The hydraulic cylinders are drilled and ported to form a hydraulic supply pressure manifold system. Length of the cylinder stroke in this arrangement depends upon the gas pressures against which the gas pistons are working and on the pressure supplied to move the hydraulic piston against the gas pressures. "Full stroking" action takes place only when inlet gas pressure is a minimum and outlet gas pressure is a maximum. At this time, the compression ratio between stages is a maximum. Increases in inlet pressure reduce the stroke length. Such stroke length changes are caused by the constant hydraulic drive force producing only a fixed amount of gas-pressure lift, thereby providing a self-compensating action by proportionate decreases in the compression ratio. Drive principle employed in gas booster compressor developed by Haskel Engineering and Supply Co., Glendale, Calif.

Segmented rotary blade folds up on impact with a solid object to prevent damage to drive shaft. Outer sections of the blade are pivot-mounted to the main blade and, under normal operation, are kept in alignment with the main blade by centrifugal force. When the tip hits an obstruction, it folds back about the pivot to slide by the obstruction with minimum impact. When the obstruction is passed, the tip swings back into place. Segmented blade principle employed in the Homko rotary mower developed by Western Tool and Stamping Co., Des Moines, Iowa.

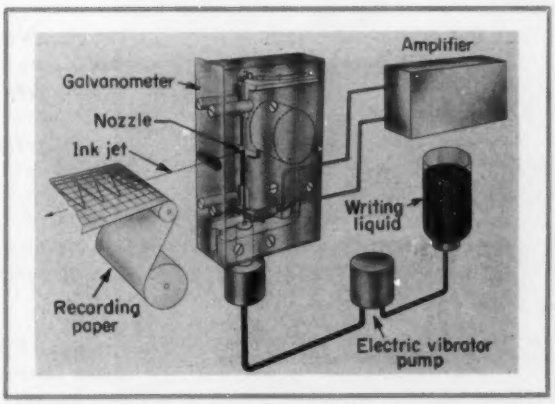


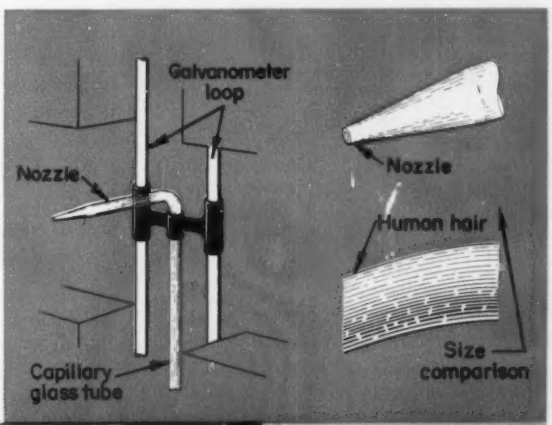
Punched metal cards replace conventional mechanical timer to permit selective variation of sequence control. Prepunched cards have five tracks which are scanned mechanically to control five different machine operations. Length and distribution of holes determine duration and timing of operations. The cards are fed through the scanning mechanism by a sprocket which engages a lengthwise perforation. A cutout pin disconnects the machine when the cover of the scanning mechanism is lifted. Card control system employed in domestic washing machines designed by Maschinenfabrik Ad. Schulthess & Co., AG, Zurich, Switzerland.

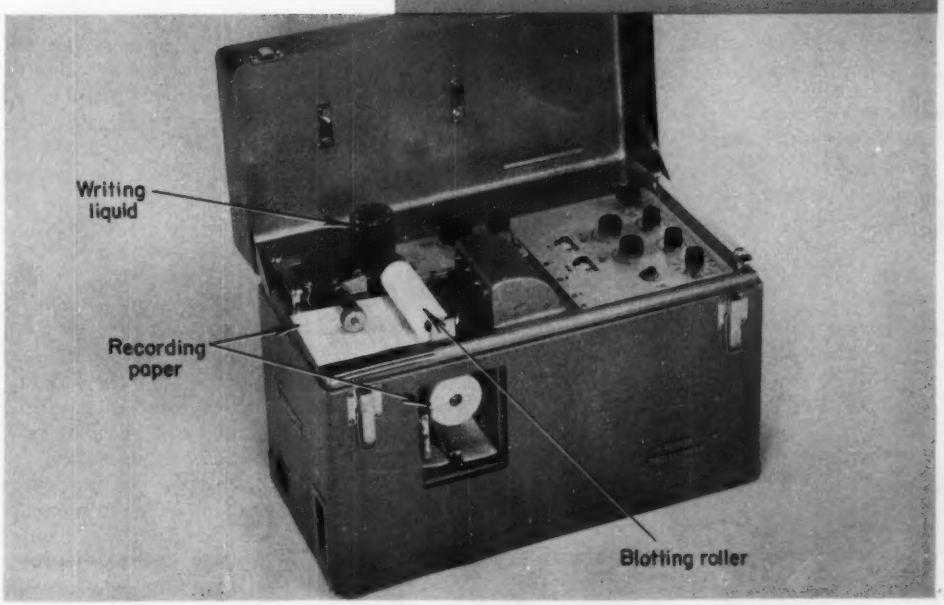




Fine ink jet from capillary glass-tube nozzle serves as the stylus in a recording instrument. Glass tube with a small-diameter right-angle nozzle is mounted between the torsion wires of a galvanometer loop. Writing liquid is fed to nozzle by electric vibrator pump. As galvanometer loop oscillates, ink jet records oscillations on moving paper. Maximum nozzle deflection is ±32 deg. A blotting roller dries recording instantly. At low writing speed, 2000 cps oscillation is superimposed on measuring current to compensate for excess liquid by widening recorded line. Ink jet principle employed in recording unit manufactured by Siemens & Halske, Karlsruhe, Germany.







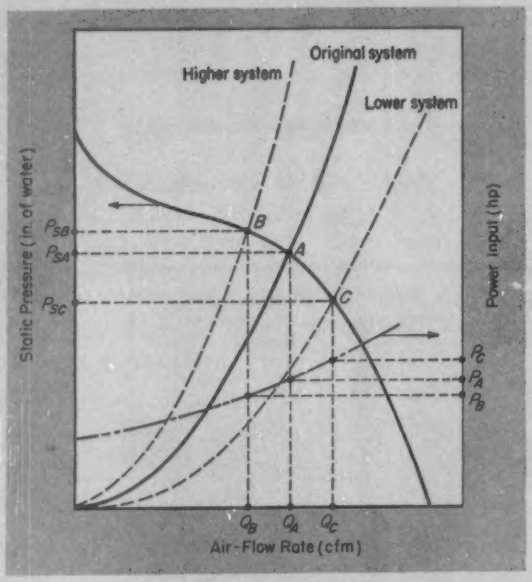


Fig. 1—Combination of static-pressure drop curves with impeller performance curve.

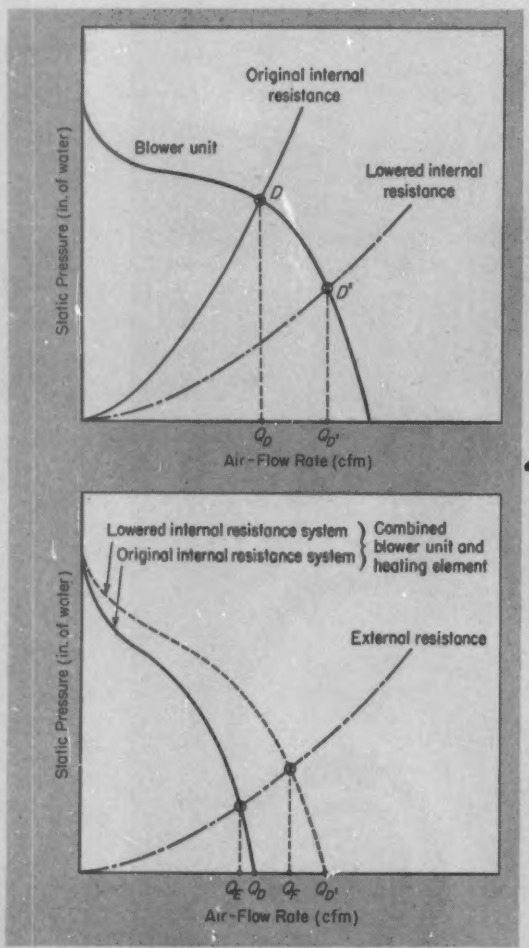


Fig. 2—System resistance curves for, *a*, internal resistance and, *b*, combined internal and external resistance.

Need to move air faster, more efficiently?

Then consider these key factors in designing . . .

air-flow paths

- *Minimum Duct Obstructions*
- *Peak Impeller Performance*
- *Optimum Heat Transfer*

DAVID A. GILDA
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AIR-MOVING systems and their individual requirements vary a great deal. Even so, there is one design problem common to all: Somehow, with a minimum of compromise, the often-conflicting performance objectives of small size, high output, and low noise level must be obtained.

The key for solving this problem lies in the design and selection of all components in the air-moving system to operate at peak performance. This is particularly true of the impeller unit and the flow path.

This article describes the nature of an air-flow path, its system resistance, and the most important air-flow elements in commercial appliances, equipment, and packaged units. Since the external portion of an air circuit is usually not within the designer's control, and since the factors involving the behavior or selection of the impeller itself have been discussed previously,[1,2] these subjects are not discussed. Performance curves for specific air-moving units are given to show the actual effects of various changes in internal air-flow paths.

Circuit Concepts

A difference in static pressure, or static-pressure head, is necessary to maintain air flow through a duct of uniform cross section A at a given average air velocity V or flow rate Q. The total static-pressure differential across the air-flow path must equal the static-pressure losses due to both the boundary friction and air turbulence at a specific flow rate. In addition, pressure losses occur in elbows, filters, grills, and other interruptions in an air-flow path. These must also be included in the pressure-loss analysis. All losses, whether frictional or turbulent, are proportional to the square of the flow rate, $P_s = K_1Q^2$, or air velocity, $P_s = K_2V^2$, where the values of K are constant for a given air-flow path regardless of the path variation between discharge and inlet. As shown by the original-system curve in Fig. 1, total static-pressure drop across a given air-flow path (the sum of all static-pressure losses) can be plotted on the graph with the performance curve for a particular impeller unit operating at a given speed. The principle operating point for an impeller is at the intersection between the system-resistance curve and the performance curve. The location of operating point A, Fig. 1, shows that the impeller introduces static pressure P_{sA}, which is required to maintain air-flow rate Q_A in the original system, and consumes power H_A.

High and Low Air Flow: The resistance curve for the higher system, Fig. 1, represents an air-flow path in which more static pressure is necessary to produce the same air-flow rate, or in which the same impeller maintains smaller air-flow rate Q_B at operating point B. Such an increase in system resistance can be caused by additional obstructions, sharper elbows, or air-flow paths that are smaller in cross section and include more boundary irregularities. On the other hand, a smoother, more open air-flow path (lower-system curve, Fig. 1) will provide superior performance.

A significant design factor is shown in Fig. 1: Some leeway is available when locating the operating point, even though the performance curve of the impeller is fixed. Hence, proper design of the air-flow path can mean the difference between satisfactory flow rate Q_C and unacceptable flow Q_B in an air-moving unit with the same over-all space.

Internal and External Flow Paths: A complete air-flow path encompasses air movement from the impeller discharge to its intake. Hence, there are then two distant flow sections in any air-moving unit that is not fully enclosed: 1. An internal flow path, for which the designer is responsible, and 2. An external flow path, over which the designer usually has no control.

The internal and external flow paths of a hypothetical air-moving appliance, whose major components are a blower unit and a heating element, may be separated as shown in Fig. 2. The original internal-resistance curve, Fig. 2*a*, represents the resistance imposed only by the internal path of the appliance as a function of flow rate. Flow rate Q_D at the operating point D is the appliance output without the addition of any external resistances—ducts, elbows, noise-attenuators, cooling coils, or outlet grills.

[1]References are tabulated at end of article.

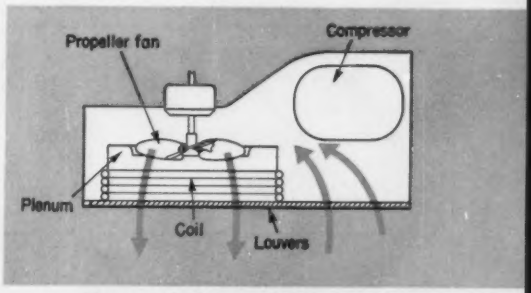

Fig. 3—Air-flow paths on the condenser and evaporator sides of a room air conditioner.

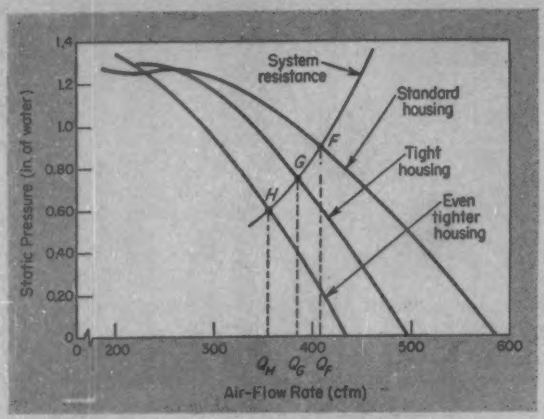

Fig. 4—Influence of housing size on air flow.

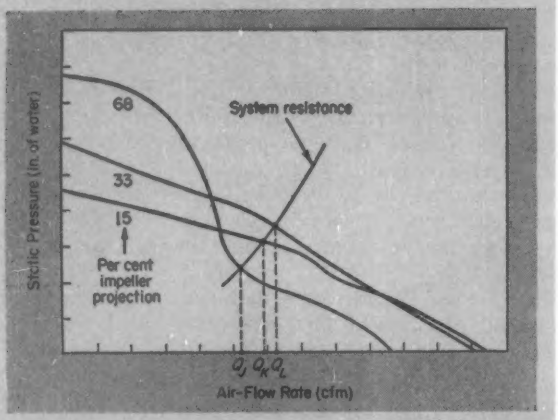

Fig. 5—Effect of impeller placement or location on air flow.

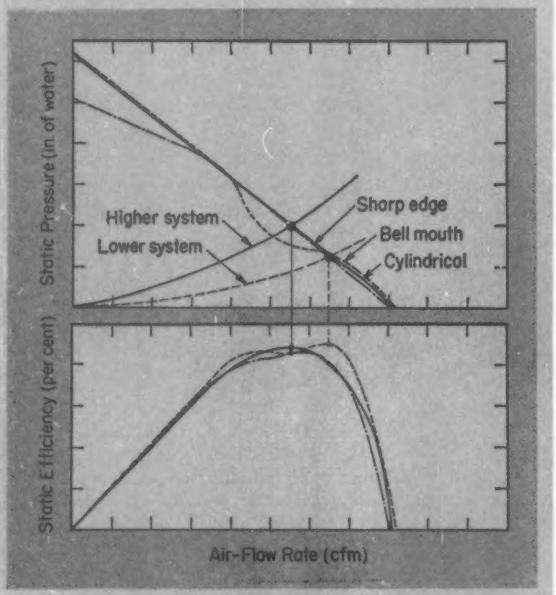

Fig. 6—Types of blower-wheel housings and their influence on air flow.

air-flow paths

Location of point D can be shifted by changing the amount of internal resistance in the unit. With careful design, the air resistance of the heating element can be reduced as shown by the lowered internal-resistance curve, and the air-flow rate through the unit can be raised to Q_D'.

In Fig. 2*b*, the two performance curves of the air-moving appliance—combined blower unit and heating element—represent operation under any external pressure conditions with either the original internal-resistance system or the lowered internal-resistance system. For any external resistance, the appliance with the lowered internal-resistance system will produce a higher air-flow rate than obtained with the original internal-resistance system.

Practical Interpretation: The air-flow paths in packaged air-moving units are usually short, small, and have varying cross-sectional areas, change direction abruptly, and have irregular boundaries. For example, the schematic drawing in Fig. 3 shows the air-flow paths on the condenser and evaporator sides of a typical room air conditioner. The air-flow path is constricted and irregular. Hence, it would be difficult to determine theoretically the total static-pressure drops of the various design possibilities. Therefore, tabular and graphical data on pressure losses in long-duct air systems are of little practical use.

A better approach is to apply good engineering practice in the design of the internal air-flow path, so that energy losses in the flow path are minimized for the known design limitations. Then, air-flow tests should be made on prototype units. The results of such tests are used to attain optimum performance in the final design. Although the basic capability of most air-moving units is always established in the original design, performance can often be significantly upgraded with very minor changes at the prototype test stage.

The two most common objectives today in designing air-moving equipment are: Maximize air flow and minimize noise. Three fundamental rules help the designer achieve these objectives: 1. Make the air flow path as wide-open, smooth and unobstructed as possible. 2. Get peak performance out of the specified air impellers. 3. Plan proper air distribution for optimum heat transfer. Following these three rules of design, of course, will not guarantee that the prototype air-moving device will deliver as much air and operate as quietly as originally specified. Hence, it may be necessary to make changes in the design. However, these rules will usually result in feasible initial design.

Minimum Duct Obstructions

Because air-flow paths in commercial air-moving devices are usually short and have relatively small

wall-surface areas, energy losses or static-pressure drops due to friction or viscous drag at the walls is not a major contributor to total static-pressure drop. Often, however, obstacles and frequent changes of direction increase air turbulence, causing comparatively large eddy losses (internal friction in the air).

Grills, filters, louvers, and other necessary components of air-flow paths can often inhibit the performance of an air-moving unit by introducing an excessive static-pressure drop. The source of difficulty is often a mainly decorative element such as a grill or louver with too little open space. Good performance is insured if each of these elements in the air-flow path is designed so that the free flow of air is interrupted as little as possible. Continuing development work is being done, for example, to produce effective air filters having a more open mesh.

Constrictions in the air-flow path can also have a significant effect on the level of air noise. To sustain a given air-flow rate in the air-flow path, the instantaneous air velocity increases whenever and as long as the cross-sectional area is reduced. High air velocities at constrictions—intakes to fans or blower wheels—can result in "high-system" noise. High-system noise can be reduced only to the extent that the air-flow path can be opened up to avoid excessive velocities.

Air swish or whistle due to excessive air velocity can occur in a blower wheel if a coil, filter, or other obstruction in the air-flow path is too close to the inlet. An increase in the space between the blower-wheel inlet and the coil or filter can eliminate air swish. If there is insufficient space in the unit, it may be necessary to select a different type or size of housing inlet ring or move the impeller further back in the housing. In a propeller fan, so-called "blade-frequency" noise can be produced if motor struts, compressor tubing, or wiring in the air-flow path is located too close to the rotating blades.

Peak Impeller Performance

Peak performance can be attained from a given blower wheel or fan in two ways: 1. Select, wherever possible, a standard housing or orifice and refrain from on-the-spot modifications. 2. Provide sufficient conversion to static pressure, which is normally of concern only with propeller fans.

Standard blower-wheel housings and fan orifices are recommended because they insure the greatest flow rate, lowest sound level, and highest efficiency. A housing or orifice that is designed especially for a particular impeller collects the air so that the full impelling capacity of the wheel or fan is used. Any change in the design of the standard housing or orifice, or in the recommended position of the impeller, reduces the output of the impeller unit.

In addition to collecting the air and feeding it into the wheel blades, a blower-wheel housing also converts velocity pressure to static pressure. A blower unit, including the wheel and a fully developed scroll, is then considered a high-pressure impeller. A propeller fan like that in Fig. 3, however, is an inherently low-pressure impeller because it has no equivalent built-in means of pressure conversion. Most commercial air-moving units, except free-air impellers (kitchen ventilators and room fans) must operate against relatively high static-pressure drops in the air-flow path. Therefore, although a blower unit usually provides a high enough static pressure, it is often necessary to introduce a means of pressure conversion at the discharge of a propeller fan.

Standard Blower-Wheel Housings: The three curves in Fig. 4 show the results of pressure-flow tests on a particular blower wheel in a standard housing, and in two smaller housings in which the air was not given sufficient space for proper movement and pressure conversion. Even though neither the blower wheel nor the system resistance of the air-flow path were changed, the desire to save space with a smaller housing resulted in a loss of flow from Q_F to either Q_G (tight housing) or Q_H (even tighter housing). A tight or improperly designed housing scroll may cause "blade-frequency" noise in the blower wheel because of poor air pressure distribution between the scroll and periphery of the wheel. In addition, noise can be produced by the air crossing the cut-off in a tight housing.

Standard Orifices and Impeller Position: The three types of orifices commonly used with propeller fans are: 1. Sharp-edge orifice (a hole cut in the wall isolating the intake and discharge), 2. Cylindrical orifice, and 3. Bell-mouth orifice. Both of the latter types have sufficient axial depth to smooth the air flow into the fan on the intake side. The sharp-edge orifice is usually specified to achieve low forming cost where noise is of no consequence. The bell-mouth orifice produces somewhat higher static pressures and efficiencies in the usual fan operating range. The propeller-fan orifice is part of the air-moving unit itself and, therefore, is usually not purchased with the impeller.

The flow output of a propeller fan into a given air-flow path depends on the following orifice conditions: Clearance between the impeller blade tops and orifice, axial depth (cylindrical and bell-mouth orifices), and position of the impeller in the orifice. Flow tests indicate that propeller fan performance will be optimum when the following orifice conditions are established:

Tip Clearance—As clearance increases between the impeller blade tips and orifice, a higher leakage of air from discharge to intake produces a reduced flow rate for a given pressure difference across the fan. Fans

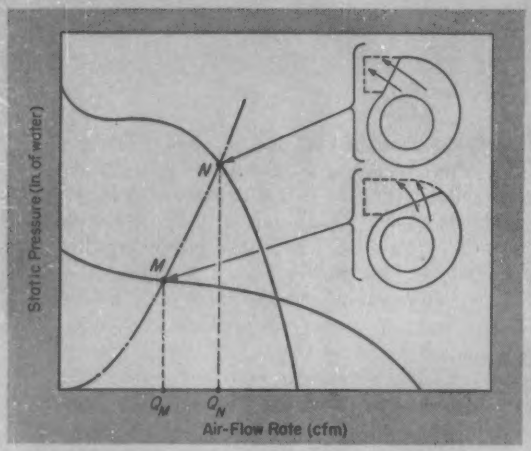

Fig. 7—Influence of housing cut-back on the over-all system performance.

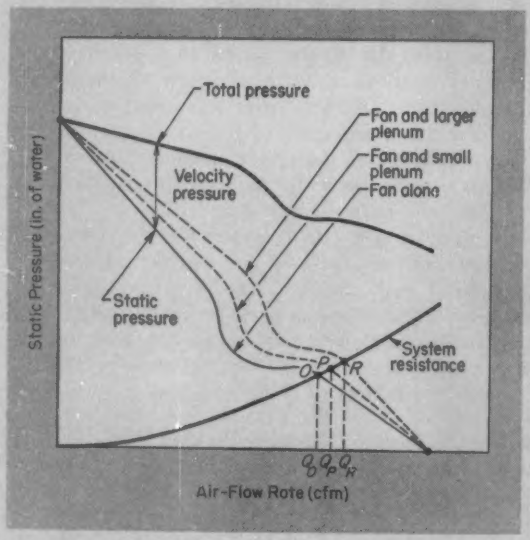

Fig. 8—Proper pressure conversion depends on relationship between plenum and fan.

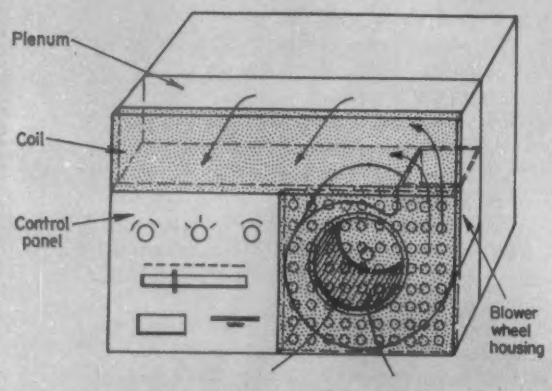

Fig. 9—Plenum of blower wheel used to increase air distribution.

with zero tip clearance would therefore be desirable but impracticable to produce. It has been found that a tip clearance of from 1.5 to 2.0 per cent of blade diameter offers very nearly zero-clearance performance while permitting normal manufacturing variations.

Axial Depth—A cylindrical orifice with an axial depth about two-thirds of the fan blade depth takes sufficient advantage of the cylindrical form without using too much material. A sharp-edge orifice, of course, has negligible axial depth anyway. The axial depth or bell radius of a bell-mouth orifice is recommended as 10 per cent of the blade tip diameter of the fan. Greater axial depth produces insufficient improvement in fan performance, while clearances below 10 per cent reduce the static efficiency of the fan through a loss of the flow-smoothing effect of the orifice curvature.

Fan Position in Orifice—Between 30 and 35 per cent of the blade depth should project out of the intake side of any of the three orifice types.

The importance of the position of the impeller in the orifice is demonstrated in Fig. 5. A propeller fan was tested in three positions in a sharp-edge orifice—protruding on the intake side 68, 33, and 15 per cent. Since the position of the fan in the orifice has negligible effect on the amount of space used for the air-flow path, a higher air-flow rate can be obtained by proper fan placement. A projection of 68 per cent, Fig. 5, on the intake side of the orifice produces a higher pressure-flow curve at very low flow rates. However, commercial air-moving equipment usually operates in the region of the indicated system-resistance curve.

The point of operation on the fan performance curve is used to determine the proper type of orifice for a given application. Fig. 6 shows performance curves for a propeller fan with each of the three orifice types. For the lower system, highest efficiencies are obtained with the bell-mouth orifice. For the higher system, either a cylindrical or a sharp-edge orifice is used to avoid the deep stall region in the bell-mouth curve. The cylindrical orifice is preferred to the sharp-edge type when a lower sound level is required.

Housing Modifications: Although a standard blower-wheel housing is used, it may be necessary to cut back the discharge opening of the housing to fit the blower unit into the space available in the air-flow path. To save space or change the direction of air flow at the discharge, the housing can be cut back as shown in Fig. 7. However, the hypothetical performance curves, Fig. 7, show that a small cut-back in the housing discharge radically reduces the static-pressure and air-flow rate.

Pressure Conversion in Plenum: Pressure conversion may be accomplished on the discharge side of a propeller fan by providing an air-collection space, commonly called a plenum. Air is usually dicharged into a plenum by a propeller fan at a relatively

high velocity. As more air is forced into the space, the internal or static air-pressure builds up. The static pressure build-up in the plenum for a particular propeller fan, size of plenum space, and outlet reaches a characteristic equilibrium level. The plenum outlet may be either larger or smaller than the discharge area of the propeller fan. It must be larger, of course, if air is to be fed into the flow path at a higher static pressure.

In Fig. 8, the static-pressure curve for the propeller fan with no plenum space provides flow output Q_o. The velocity pressure at any flow rate is the difference between the static and total pressures produced by the impeller. Addition of a small plenum raises the performance curve and operating point to point P. Even higher flow Q_R is achieved with a larger plenum. The performance curve of the fan alone has not been changed by the plenum in any way, but the static-pressure curve of the fan and plenum together approaches the total-pressure curve of the fan alone as the velocity pressure is more completely converted.

Optimum Heat Transfer

The fundamental function of the air-flow path, in most cases, is to produce the most usable distribution of air at the right place to accomplish some kind of heat transfer. Thus, the propeller fan in the room air conditioner in Fig. 3 must blow the air uniformly through the coil to dissipate heat.

Over the usual range of ambient conditions, it can be shown that heat transfer (W) in watts for either cooling or heating coils is

$$W = K \frac{V^p}{R^N} A(\Delta T) \qquad (1)$$

where K is constant for a particular system; R = hydraulic radius of flow cross section, ft; V = average air velocity, fpm; A = total coil surface area, sq ft; and ΔT = difference in temperature between the moving air and coil surface, deg F. The exponent p is about 0.6 for the usual fan-coil heat-transfer conditions and $N = 0.4$.

For a given temperature difference between the air and coils, Equation 1 indicates that the heat-transfer rating of an air-moving unit can be raised by increasing either the coil exposure area, or the air velocity, or by reducing the hydraulic radius. The coil exposure area might be raised, but this method usually is more expensive and less effective than the other two. If the same size impeller is used, the increased static pressure will reduce the air-flow rate or the air velocity, which was originally assumed constant for the coil exposure area change, and thereby result in a lower heat transfer. The lateral coil area is limited by the outside dimensions of the air-moving unit. For example, in Fig. 9, the area of the coil on the evaporator side of the air conditioner is about as large as possible, and sufficient space is allowed for the blower-wheel intake and other components behind the control panel.

A higher air velocity is not usually a satisfactory way to increase the heat-transfer rating. It is relatively ineffective, due to the exponent $p = 0.6$, and can create new problems of noise and additional resistance losses.

A reduction in the hydraulic radius, which represents the lateral cross-sectional area of air flow through the coils, is often the easiest way to improve heat transfer. This, for example, could be accomplished by increasing the number of fins in a room air conditioner coil. This would, however, increase the static resistance.

Often, after an entirely adequate coil size is specified for the desired level of heat-transfer, the air-flow path is inadvertently designed so that only part of the coil is actually being used. As a result, performance is disappointing. The usual cause of such a condition occurs when the propeller fan or blower wheel is discharging directly into the coil, although its discharge area is neither as large nor of the same shape as the coil. Heat transfer can be improved by

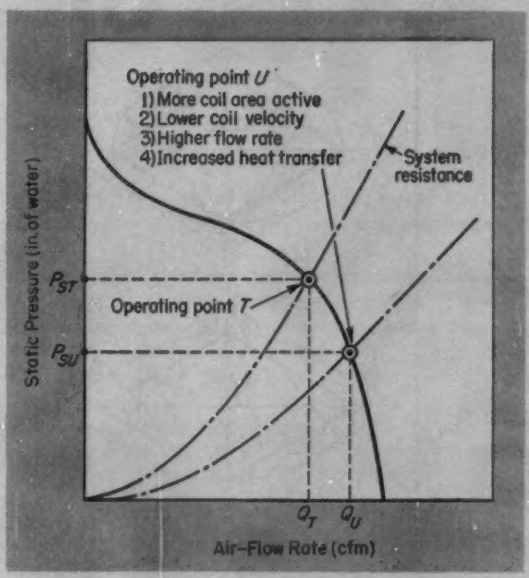

Fig. 10—Effect of improved air distribution over a coil.

space on the impeller discharge to expand air distribution. The coil in Fig. 3 would be inactive if the propeller fan dicharged directly into the coil without an intervening plenum space. The plenum placed on the discharge of the blower wheel, Fig. 9, both expands the air distribution over the full coil area and changes the direction of the housing discharge.

Air distribution across coils, as well as along irregular flow paths, can frequently be improved by proper use of guide vanes.

The performance curve, Fig. 10, shows graphically the effect of improved air distribution over a coil, whether it is produced by adding plenum space or guide vanes, or simply by rearranging components in the air-flow path. The impeller, originally operating at point T on its performance curve, must overcome a total pressure drop in the air-flow path of P_{sT} to maintain an air flow of Q_T. Since the distribution on the impeller discharge is so poor, only a fraction of the coil is active. Expansion of the

air-flow paths

air-flow cross section, and full use of the coil, shifts impeller operation to point U on a lower system because of the reduced static-pressure drop across the coil. A more active coil area (larger hydraulic radius) means a lower velocity through the coil, unless the increase in velocity due to higher flow rate Q_U more than offsets the reduction in coil velocity due to the greater flow area. Since the increase in flow area is more effective in heat transfer than the resulting decrease in velocity, the heat-transfer capacity of the air-moving unit is increased.

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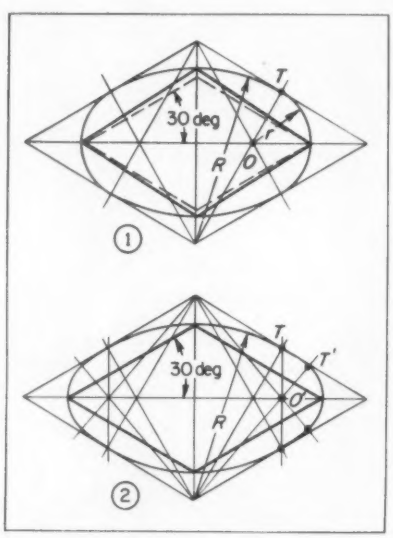
1. K. A. Merz—"Basic Factors in Air-Circuit Design," MACHINE DESIGN, June 28, 1956, pp. 139-145.
2. C. A. Hathaway—"How To Select Air Impellers for Optimum Performance," MACHINE DESIGN, October 4, 1956, pp. 88-94.

Tips and Techniques

Isometric Square Construction

Construction of a square in the conventional isometric circle, Fig. 1, by joining the ends of the major and minor axes of the construction ellipse results in the sides not being at 30 degrees with the major



axis. Consequently, sides of the internal square are not parallel to other lines in the drawing. To draw a circle in the resulting square would require an improvised construction.

Fig. 2 shows a modified ellipse that allows 30-degree lines to be used in construction. The large radius, R, is extended to either side, and a new center, O', for smaller radius, $O'T'$, is found by drawing a line through T perpendicular to the major axis. Lines are drawn from the two opposite corners of the square, through O', cutting the large radius, R, at T'. Length $O'T'$ is the new radius permitting construction of the sides of the square at 30 degrees. —F. MURRAY, Chicago, Ill.

Volumes of Solids

The volumes of solids of revolution can quickly be found by using the following table.

$$V = A^2X^2Y$$

Solid	X	Y	A
Sphere	Radius	Radius	2.047
Cone	Radius of base	Height	1.023
Ellipsoid	Radius of rev.	Half Length	2.047
Paraboloid	Radius of base	Height	1.253
Cylinder	Radius	Height	1.772

Direct slide rule evaluation may be used by setting X on the CI scale opposite A on the D scale. Opposite Y on the B scale, read V on the A scale.—JESSE ROTH, *New York, N. Y.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Dynamic Acceleration Analysis

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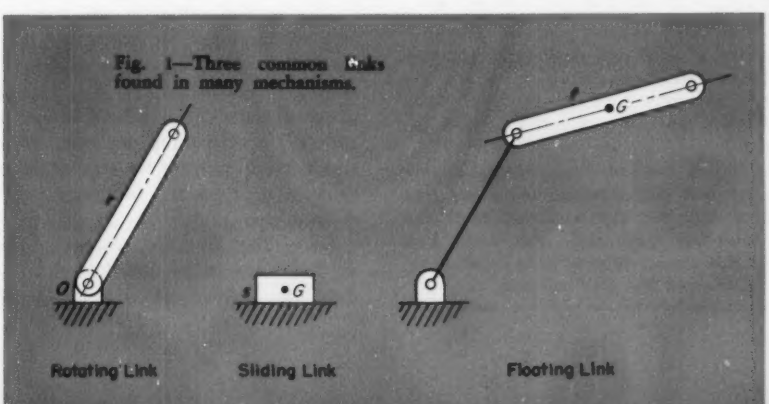
Accelerations in mechanisms are generally determined from the known motion of at least one part. But if only the forces acting on one or more parts are known, and not the motion, the problem cannot be solved by the usual procedures of kinematics. Several methods, involving graphical steps, have been available.
Now, here's an accurate, analytical method.

FREQUENTLY the designer is confronted with the problem of predicting the dynamic behavior of a mechanism from knowledge of the forces acting on one or more of the links, without being able to assume the acceleration of any one link. An example is the investigation of the dynamic response of a mechanism at the start of the motion, or during acceleration and deceleration.

The method of dynamic analysis, described here, forms a basis of solution for these problems. Two procedures are developed: One for impending mo-

Fig. 1—Three common links found in many mechanisms.



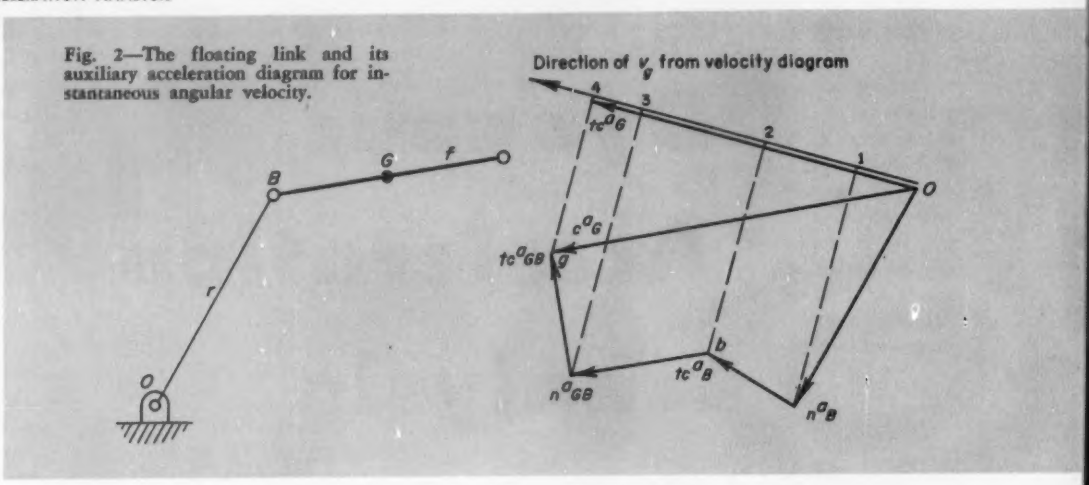


Fig. 2—The floating link and its auxiliary acceleration diagram for instantaneous angular velocity.

tion, and one, for some instant at which the mechanism has already acquired finite kinetic energy. Both methods are based on the law of conservation of energy: The time rate of change of kinetic energy of the mechanism is equal to the instantaneous power input of the external force system. Or,

$$\sum \frac{dE_r}{dt} + \sum \frac{dE_s}{dt} + \sum \frac{dE_f}{dt} = \sum {}_tF_k(v_{Pk}) + \sum T_k \omega_k \qquad (1)$$

where ${}_tF_k$ is the component of F_k in the direction of v_{Pk}. The appropriate energy equations for the three basic link types shown in Fig. 1, are:

For the rotating link,

$$E_r = \frac{I_O \omega^2}{2} \qquad (2a)$$

$$\frac{dE_r}{dt} = I_O \omega \alpha \qquad (2b)$$

For the sliding link,

$$E_s = \frac{M v_G^2}{2} \qquad (3a)$$

$$\frac{dE_s}{dt} = M v_G a_G \qquad (3b)$$

For the floating link,

$$E_f = \frac{I_G \omega^2 + M v_G^2}{2} \qquad (4a)$$

$$\frac{dE_f}{dt} = I_G \omega \alpha + M v_G {}_ta_G \qquad (4b)$$

Instant of Impending Motion: As the first step in the determination of the accelerations, an auxiliary acceleration diagram for the mechanism is constructed, based on the arbitrarily selected input angular acceleration, ${}_c\alpha_i = 1$ rad per sec^2. Because of the absence of angular velocities, all normal (centripetal) accelerations are zero. Hence, the auxiliary acceleration polygon is similar in all respects to a velocity polygon for the same configuration of the mechanism.

From the diagram, values of ${}_c\alpha_k$ and ${}_ca_{Gk}$ for all links are easily determined. The true values of these quantities are directly proportional to the

Nomenclature and Conventions

a_G = Absolute acceleration of G, in. per sec^2
${}_na_G$ = Normal (centripetal) component of ${}_aa_G$, in. per sec^2
${}_ta_G$ = Tangential component of a_G, in. per sec^2
E = Kinetic energy of link, in.-lb
F = External force on link, lb
I_G = Moment of inertia of link with respect to an axis, perpendicular to the plane of motion, through its center of gravity G, lb-in. sec^2
I_O = Moment of inertia of link about its fixed pivot O, lb-in. sec^2
M = Mass of link, lb
P = Point of application of ${}_aF$
T = External torque on link, lb-in.
v_G = Absolute velocity of G, in. per sec
W = Weight of link, lb
α = Absolute angular acceleration of link, rad per sec^2
ω = Absolute angular velocity of link, rad per sec

Other subscripts:
c = Chosen arbitrarily
f = Floating
i = Input
k = A link in general
r = Rotating
s = Sliding

Rotational quantities ω, α, T are positive if counterclockwise. For translational quantities (v, a, F), the positive direction is determined by the velocity. Tangential components are positive if directed in the same sense as the velocity.

The term *input link* is used to denote the particular link whose velocity and acceleration are chosen as convenient starting data for the construction of the velocity and acceleration diagrams. The input link is not necessarily the actual driving link. Generally, a rotating link is selected for this purpose.

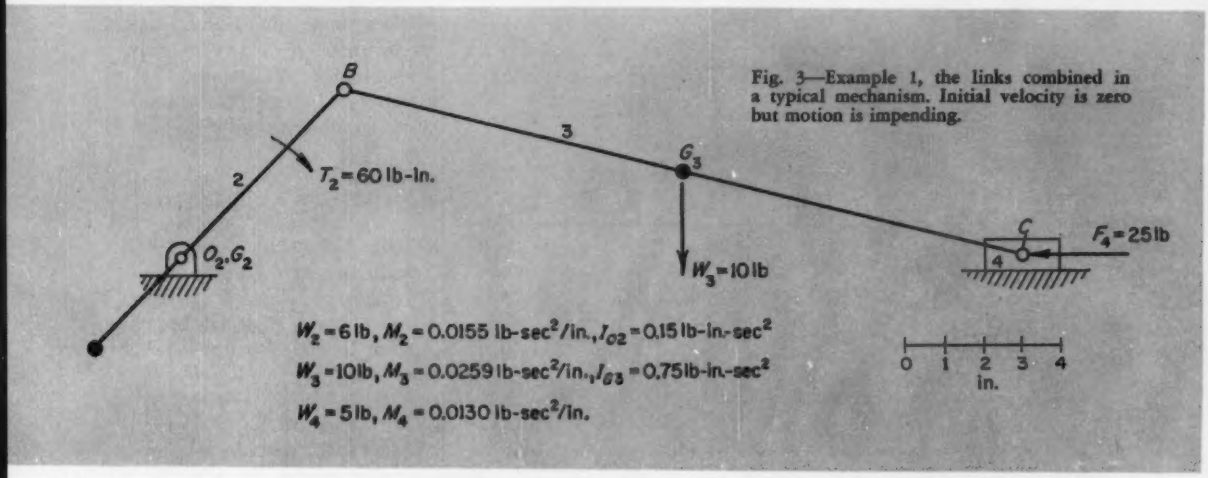


Fig. 3—Example 1, the links combined in a typical mechanism. Initial velocity is zero but motion is impending.

still unknown input angular acceleration:

$$\alpha_k = \alpha_i \frac{{}_c\alpha_k}{{}_c\alpha_i} = \alpha_i \, {}_c\alpha_k \tag{5a}$$

$$a_{Gk} = \alpha_i \frac{{}_c a_{Gk}}{{}_c\alpha_i} = \alpha_i \, {}_c a_{Gk} \tag{5b}$$

where ${}_c\alpha_i = 1$. Substitution of Equations 5, 4, 3, and 2 into 1 leads to

$$\alpha_i \left\{ \sum I_{Or} \omega_r \, {}_c\alpha_r + \sum M_s \, v_{Gs} \, {}_c a_{Gs} + \sum I_{Gf} \omega_f \, {}_c\alpha_f + \sum M_f \, v_{Gf} \, {}_c a_{Gf} \right\} = \sum {}_t F_k \, v_{Pk} + \sum T_k \, \omega_k \tag{6}$$

Equation 6 contains angular and translational velocity terms. It is true that at the instant of impending motion these are zero. However, after an infinitesimal time interval, dt, the links acquire infinitesimal velocities, which, because of the previously mentioned similarity, have the same directions and relative magnitudes as the corresponding accelerations:

$$\omega_k = {}_c\alpha_k \, dt \tag{7a}$$

$$v_{Gk} = {}_c a_{Gk} \, dt \tag{7b}$$

$$v_{Pk} = {}_c a_{Pk} \, dt \tag{7c}$$

With these relations, Equation 6 reduces to:

$$\alpha_i \left\{ \sum I_{Or} \, {}_c\alpha_r{}^2 + \sum M_s \, {}_c a_{Gs}{}^2 + \sum I_{Gf} \, {}_c\alpha_f{}^2 + \sum M_f \, {}_c a_{Gf}{}^2 \right\} = \sum {}_t F_k \, {}_c a_{Pk} + \sum T_k \, {}_c\alpha_k \tag{8}$$

Since all other quantities in this equation are known, α_i can be calculated.

Input Link with an Instantaneous Angular Velocity: The first step is to construct the actual velocity polygon and an auxiliary acceleration polygon, with an assumed angular input acceleration, ${}_c\alpha_i \neq$ zero, from which the quantities ${}_c\alpha_k$ and ${}_c a_{Gk}$ for all links are calculated. The reason for making ${}_c\alpha_i$ nonzero is given later. Due to the finite angular velocities and consequent normal accelerations, a change in the input angular acceleration from ${}_c\alpha_i$ to α_i does not produce proportional changes in the angular accelerations of the other links, as was the case at the instant of impending motion. That is, here $\alpha_k \neq (\alpha_i / {}_c\alpha_i) \, {}_c\alpha_k$.

The complex relationship that exists between these two acceleration systems has been investigated by Goodman.[1] His transformation equations are adapted here to a mechanism with a rotating input link and with auxiliary accelerations based on the actual velocities.

Angular accelerations:

$$\alpha_k = \frac{\omega_k}{\omega_i} (\alpha_i - {}_c\alpha_i) + {}_c\alpha_k \tag{9a}$$

or

$$\frac{\alpha_k}{{}_c\alpha_k} = \frac{\omega_k}{\omega_i} \left(\frac{\alpha_i - {}_c\alpha_i}{{}_c\alpha_k} \right) + 1 \tag{9b}$$

Translational accelerations:

$$a_{Gk} = \frac{v_{Gk}}{\omega_i} (\alpha_i - {}_c\alpha_i) + {}_c a_{Gk} \tag{10a}$$

or

$$\frac{a_{Gk}}{{}_c a_{Gk}} = \frac{v_{Gk}}{\omega_i} \left(\frac{\alpha_i - {}_c\alpha_i}{{}_c a_{Gk}} \right) + 1 \tag{10b}$$

With the aid of these equations, the expressions for the time rate of change of kinetic energy for the three basic link types can be transformed.

For the rotating link,

$$\frac{dE_r}{dt} = I_{Or} \omega_r \alpha_r = I_{Or} \omega_r \left[\frac{\omega_r}{\omega_i} (\alpha_i - {}_c\alpha_i) + {}_c\alpha_r \right] \tag{11a}$$

[1]References are tabulated at end of article.

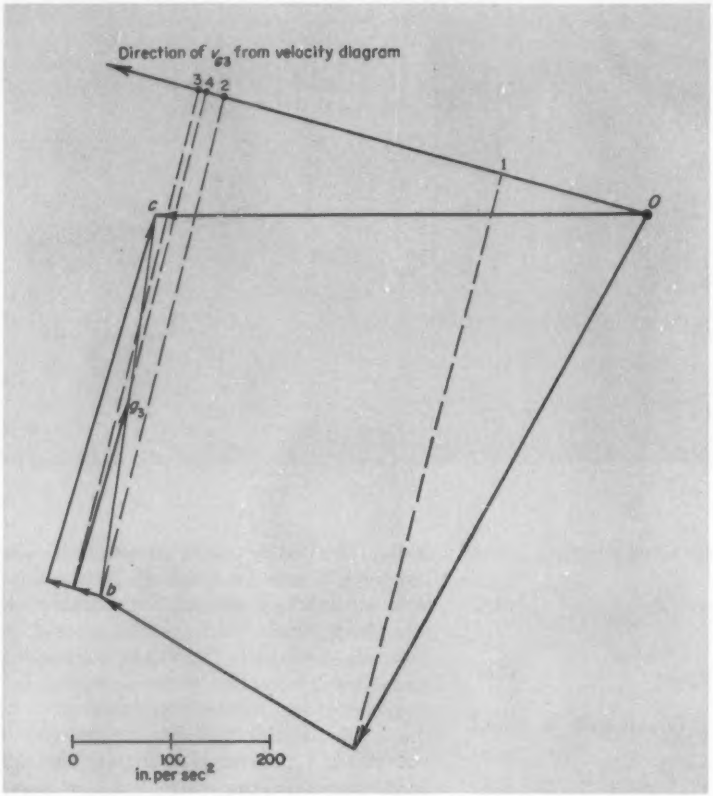


Fig. 4—Auxiliary acceleration diagram for Example 1.

For the sliding link,

$$\frac{dE_s}{dt} = M_s\, v_{Gs}\, a_{Gs}$$

$$= M_s\, v_{Gs} \left[\frac{v_{Gs}}{\omega_i} (\alpha_i - {}_c\alpha_i) + {}_c a_{Gs} \right] \qquad (11b)$$

Shown in Fig. 2 is a floating link and the relevant portion of the auxiliary acceleration diagram, based on the actual velocity polygon. The acceleration vector of center of gravity G is compounded from component vectors in accordance with

$${}_c a_G = {}_c a_B + {}_c a_{GB}$$

$$= {}_n a_B + {}_{tc} a_B + {}_{nc} a_{GB} + {}_{tc} a_{GB}$$

Only the tangential acceleration components are affected by a change of the input acceleration. Therefore,

$$\frac{dE_f}{dt} = I_{Gf}\, \omega_f\, \alpha_f + M_f\, v_{Gf}\, {}_t a_{Gf}$$

$$= I_{Gf}\, \omega_f \left[\frac{\omega_f}{\omega_i} (\alpha_i - {}_c\alpha_i) \right] + M_f\, v_{Gf} \left[\overline{(0\text{—}1)} + \overline{(1\text{—}2)} \left(\frac{\omega_r}{\omega_i} \right) \left(\frac{\alpha_i - {}_c\alpha_i}{{}_c\alpha_r} + 1 \right) + \overline{(2\text{—}3)} + \overline{(3\text{—}4)} \left(\frac{\omega_f}{\omega_i} \right) \left(\frac{\alpha_i - {}_c\alpha_i}{{}_c\alpha_f} + 1 \right) \right] \qquad (11c)$$

In this equation the vector projections $\overline{(0\text{—}1)}$, $\overline{(2\text{—}3)}$, etc., are considered positive if directed in the same sense as v_{Gf}. Substitution of Equation 11 *a*, *b*, and c into Equation 1 yields an equation from which α_i, as the only unknown quantity, can be calculated.

It is conceivable that, with the assumed value of ${}_c\alpha_i$, one or the other angular acceleration may become zero, causing the corresponding vector projection, such as $\overline{(1\text{—}2)}$ or $\overline{(3\text{—}4)}$ in Fig. 2 to vanish. This is the reason for making ${}_c\alpha_i \neq$ zero. The easiest way out of this difficulty is to construct a new acceleration diagram with a different value of ${}_c\alpha_i$.

Example 1: Determine the angular acceleration of crank 2, Fig. 3, assuming that it starts from rest. The auxiliary acceleration diagram, Fig. 4, is based on $\omega_2 = 0$ and ${}_c\alpha_2 = 1$ rad per sec². It yields the following information:

For Link 2, ${}_c\alpha_2 = 1$ rad per sec², $T_2 = -60$ lb-in.
For Link 3, ${}_c\alpha_3 = -0.174$ rad per sec², ${}_c a_{G3} = 5.86$ in. per sec², ${}_t W_3 = -2.5$ lb in direction of ${}_c a_{G3}$.
For Link 4, ${}_c a_{G4} = 6.12$ in. per sec², $F_4 = 25$ lb.

Substituting into Equation 8 (recalling that subscript r applies to crank 2, s to slider 4, and f to link 3),

$$a_2[0.15(1)^2 + 0.013(6.12)^2 + 0.75(-0.174)^2 +$$

$$0.0259(5.86)^2] = 25(6.12) - 2.5(5.86) - 60(1)$$

$$a_2 = 50.5 \text{ rad per sec}^2, \text{ counterclockwise}$$

Example 2: Determine the angular acceleration of

the crank in the same position as before but assume that its angular velocity at that instant is $\omega_2 = 10$ rad per sec. With altered scales, Fig. 4 may be used as the actual velocity polygon. It yields the following information:

For Link 2, $\omega_2 = 10$ rad per sec.
For Link 3, $\omega_3 = -1.74$ rad per sec, $v_{G3} = 58.6$ in. per sec.
For Link 4, $v_{G4} = 61.2$ in. per sec.

From Fig. 5, the auxiliary acceleration polygon, with $\omega_2 = \omega_1 = 10$ rad per sec and ${}_c\alpha_2 = {}_c\alpha_4 = 50$ rad per sec^2:

For Link 2, ${}_c\alpha_2 = 50$ rad per sec^2 (assumed), $r = i = 2$.
For Link 3, ${}_c\alpha_3 = 20.6$ rad per sec^2, $r = i = 2$, $f = 3$.
Projections of a_{G3} components in the direction of v_{G3}: $\overline{(0\text{—}1)} = 157$ in. per sec^2; $\overline{(1\text{—}2)} = 290$ in. per sec^2 (to be adjusted), and $\overline{(2\text{—}3)} = 27$ in. per sec^2, $\overline{(3\text{—}4)} = 8$ in. per sec^2 (to be adjusted)
For Link 4, ${}_cA_{G4} = 502$ in. per sec^2, $i = 2$, $s = 4$.

$$\frac{dE_2}{dt} = 0.15(10)\alpha_2 = 1.50\,\alpha_2$$

$$\frac{dE_3}{dt} = 0.75(-1.74)[-0.174(\alpha_2 - 50) + 20.6] + 0.0259(58.6)\left[157 + 290\left(\frac{\alpha_2 - 50}{50} + 1\right) + 27 - 8(-0.174)\left(\frac{\alpha_2 - 50}{20.6} + 1\right)\right]$$

$$= 9.15\,\alpha_2 + 224$$

$$\frac{dE_4}{dt} = 0.013(61.2)[6.12(\alpha_2 - 50) + 502]$$

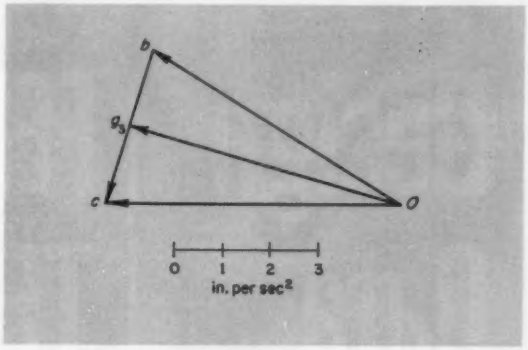


Fig. 5—Auxiliary acceleration diagram for Example 2. Initial velocity is finite.

$$= 4.85\,\alpha_2 + 156$$

The total time rate of change of kinetic energy $= 15.50\alpha_2 + 380$. The power input is 10 times as large as before, or, 784 in.-lb per sec. Hence, $15.5\alpha_2 + 380 = 784$ from which $\alpha_2 = 26.1$ rad per sec^2, counterclockwise.

Other methods of dynamic analysis, such as Wittenbauer's[2] or Quinn's[3] can be used, but involve a graphic differentiation, which limits their accuracy.

REFERENCES

1. T. P. Goodman—"An Indirect Method for Determining Acceleration in Complex Mechanisms," ASME Paper No. 57-A-108, Dec., 1957.
2. F. Wittenbauer—*Graphische Dynamik*, Verlag Springer, Berlin, 1923.
3. B. E. Quinn—"Energy Method for Determining Dynamic Characteristics of Mechanisms," *Journal of Applied Mechanics*, Vol. 16, No. 3, Sept., 1949, p. 283.

Tips and Techniques

Accelerated Multiplication

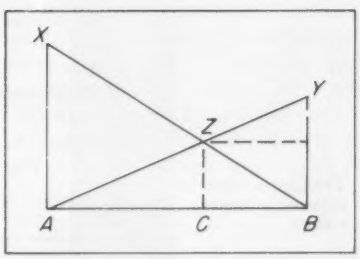
A shorthand method of multiplication which yields exact answers is demonstrated by the example,

$$487 \times 95 = 46265$$

—M. VANDERMEULEN, *Montreal, Canada*

1.	487 95 5	7·5 = 3 ⑤ (Write 5, carry 3)
2.	487 95 65	7·9 + 8·5 + 3 = 10 ⑥ (Write 6, carry 10)
3.	487 095 265	7·0 + 8·9 + 4·5 + 10 = 10 ② (Add 0, write 2, carry 10)
4.	487 095 6265	8·0 + 4·9 + 10 = 4 ⑥ (Write 6, carry 4)
5.	487 095 46265	4·0 + 4 = ④ (Write 4)

Reciprocal Equation Solution



Equations of the form $1/z = 1/x + 1/y$ can be easily solved graphically. Segment AB is laid out to any convenient length, with perpendiculars AX and AY forming the ends. The perpendiculars are made proportionate to the quantities x and y. Diagonals BX and AY then fix height ZC which is equal to the quantity z in the same proportion.—JESSE ROTH, *New York, N. Y.*

NEW Design Data for FEP TFE

Part 2—Thermal,

FEP and TFE fluorocarbon plastics are suitable for many applications requiring resistance to temperature and corrosion, and good electrical properties. The first information available on the new FEP resins is presented here, and data for TFE are also new or revised.

Effects of temperature on expansion, distortion, and elasticity of Teflon plastics are explained. Wear characteristics include hardness, fatigue, impact, and abrasion data. Resistance to arcing and high frequencies makes these plastics desirable for electrical insulation. Discussion of the exact nature of these properties and how they can be used concludes this series on Teflon. A previous article (Jan. 21, 1960) covered strength and deformation properties.

Thermal Expansion: Linear expansion of TFE and FEP fluorocarbon plastics is shown in Fig. 11. A marked change in volume of 1.0 to 1.8 per cent is evident for TFE in the transition zone from 65 to 77 F. A part which has been machined on either side of this zone will obviously change dimensions if permitted to go through the zone. Thus, final operating temperature of a precision part must be accurately determined. Measurement on a production basis must allow for this volume change if the transition zone is traversed in either manufacture or operation of the part. FEP plastics do not exhibit this peculiar expansion characteristic because they do not have a transition point.

Low-Temperature Properties: Parts fabricated of TFE resins exhibit high strength, toughness, and self-lubrication at low temperatures. Both FEP and TFE are useful from −450 F and are highly flexible from −110 F.

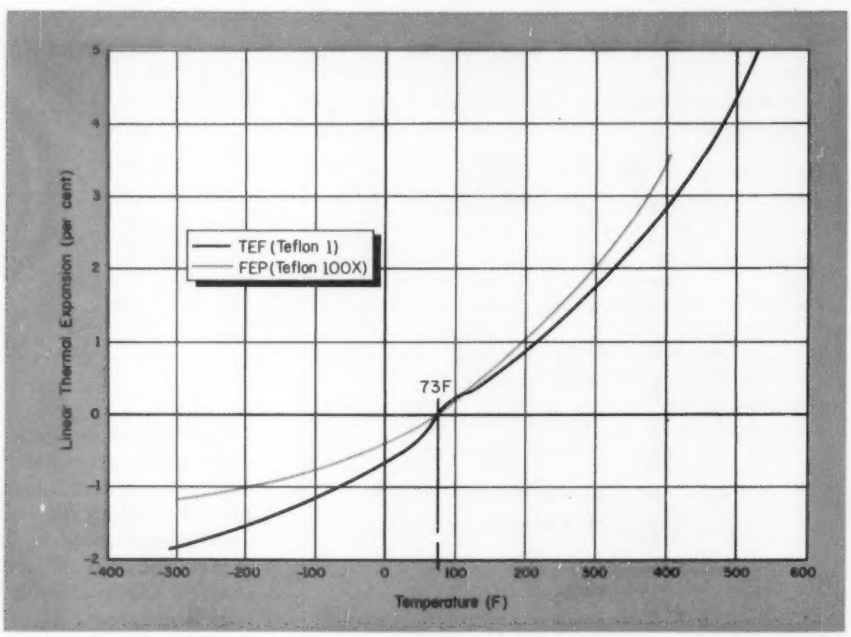


Fig. 11—Linear thermal expansion versus temperature.

Wear, And Electrical Properties

L. H. GILLESPIE, D. O. SAXTON, and F. M. CHAPMAN
Polychemicals Dept.
E. I. du Pont de Nemours & Co. Inc.
Wilmington, Del.

Thermal Conductivity and Specific Heat: Thermal conductivities of Teflon 1 (TFE) and Teflon 100X (FEP) are, respectively, 1.7 and 1.4 ±0.3 Btu/hr/sq ft/deg F/in. Heat capacity is 0.25 Btu/lb/deg F for Teflon 1 and 0.28 Btu/lb/deg F for Teflon 100X.

Heat Distortion: Temperatures obtained for heat distortion of Teflon 1 are (ASTM D 648): 252 F for a stress of 66 psi, 132 F for a stress of 264 psi. Values for Teflon 100X are: 158 F at 66 psi, 124 F at 264 psi.

Elastic Memory: Parts made from Teflon fluorocarbon resins tend to return to their original dimensions after a deformation, but the process of recovery may require a long time. A fabricated part which creeps or deforms over a period of time under stress will recover its original shape when stress is removed and the part is raised to sintering temperature. However, partial recovery will occur at lower temperatures. At any given temperature, recovery to be expected at that temperature is substantially complete in 15 minutes or less, but extent of recovery increases with increased temperature.

For example, a TFE filament 4-in. long, stretched to a length of 12 in. and heated at 212 F, recovers to approximately 11 in. within 15 min and then remains substantially unchanged. A similar piece heated to 392 F recovers to 10 in. The first piece, after additional heating to 392 F, undergoes further recovery until it is 10-in. long. When heated to 662 F, both pieces return to their original length of 4 in.

Decomposition at Elevated Temperatures: Rate of decomposition of a Teflon part depends on the particular resin, temperature, heat-exposure time, and, to a lesser extent, pressure and nature of the environment. In designs where the rate of outgassing is important, as in high-vacuum work or for safety considerations, initial rates of decomposition in Table 5 may be used. For most applications these decomposition rates are small enough below the maximum service temperature (500 F for TFE plastics and 400 F for FEP plastics), and no special precautions are necessary. Where temperatures run above 650 F during fabrication, proper ventilation is required.

Experience indicates that in many instances the rate of decomposition of an article fabricated of fluorocarbon resin decreases after continual exposure. For example, when parts made of Teflon 1, 5, and 7 are used, a very low, fairly steady decomposition rate is established after less than 1 per cent of the resin has decomposed.

Fatigue: Curves of stress versus strain are a sound basis for calculating the performance of statically loaded parts. However, they are not a good basis for design of parts subjected to repeated stress. As with ferrous alloys, there is a stress value, the fatigue endurance limit, below which Teflon plastics will not fail no matter how many times load is applied.

Typical fatigue data for fluorocarbon plastics are given in Table 6. All data were taken at constant

Table 5—Decomposition Rates at Elevated Temperatures

Temperature (F)	Rate of Decomposition (per cent per hr) FEP Teflon 100X	TFE Teflon 6, 30 Initial	TFE Teflon 1, 5, 7 Initial	TFE Teflon 1, 5, 7 Steady State
450	0.0004	0.0001 to 0.0002	0.00001 to 0.00005	1×10^{-11}
500	0.001	0.0006	0.0001 to 0.0002	100×10^{-11}
600	0.02	0.005	0.0005	0.000002
700	0.3	0.03	0.004	0.0009

Table 6—Fatigue Resistance at 73 F

Resin	Stress (psi)	Cycles to Failure
TFE (Teflon 1)	1000	>20 million
	1400	> 7 million
	1450	12,000*
	1500	1200*
FEP (Teflon 100X)	1000	> 7 million
	1400	>7.2 million
	1450	1300
	1500	960

* Yielded, but did not break.

Table 7—Tensile and Izod Impact Strength

Resin	Temperature (F)	Impact Strength—Tensile (ft-lb/cu in.)	Impact Strength—Izod* (ft-lb/in.)
TFE (Teflon 1)	73	320	2.9
	−65	105	2.3
FEP (Teflon 100X)	73	1020	Sample bends
	−65	365	2.9

* ASTM D 256-56.

Table 8—Hardness

Resin	Rockwell R Scale*	Durometer D Scale	Durometer A Scale
FEP (Teflon 100X)	25	59	96
TFE (Teflon 1)	58	52	98

*ASTM D 785-51.

Table 9—Maximum *PV* Values

Resin	PV Values*—Continuous Use	PV Values*—Intermittent Use
FEP (Teflon 100X)	600	1000
TFE (Teflon 1)	1000	3000
TFE reinforced: 25% glass-fiber-filled Teflon 1	10,000	20,000

*P in psi; V in fpm.

Table 10—Weight Loss Caused by Sliding Tape*

Resin	Average Weight Loss (gm per sq in.)
TFE (Teflon 1)	0.337
FEP (Teflon 100X)	0.174

* Armstrong abrasion test (ASTM D 1242-56): This test measures abrasion resistance of flat surfaces by drawing abrasive tape, under load, over test specimens at a slip rate of 100 in. per min. With No. 320 abrasive under a 15-lb load, weight loss was measured after 200 revolutions (1 hr 40 min).

Table 11—Weight Lost from Revolving Disk* (Cumulative weight loss in milligrams)

Resin	Test Cycles . . . 10	50	100	500	1000	2000
TFE (Teflon 1)	0.35	1.65	2.2	5.7	8.9	13.4
FEP (Teflon 100X)	0.30	0.60	1.0	3.9	7.5	13.2

* Taber abrasion test: This test measures abrasion resistance of a flat surface by rotating a 4-in. diam specimen disk beneath an abrasive under load. A 1000-gm load was used on a Calibrase wheel No. CS-17F.

Table 12—Tape Length Required To Abrade Through Wire Coating* (Average tape length in inches)

Resin	Heat aging . . . None	96 hr at 302 F	500 hr at 302 F	96 hr at 392 F
TFE (Teflon 6)	76	78	98	84
FEP (Teflon 100X)	107	94	118	87

* Tape abrasion test (MIL-T-5438): This test measures abrasion resistance of wire coatings by drawing, under load, a clean abrasive cloth tape of continuous length across the test wire until the coating is worn through. A 1-lb load on No. 400 grit tape was used on a coating thickness of 0.015 in.

maximum stress to failure with a Sonntag-Universal machine.

Impact: Ability to absorb impact energy, or impact toughness, is difficult to predict in a part because shape has a major effect on performance. Understanding how a part resists impact, however, helps in selecting a good design.

The energy of an impact has to be absorbed by a force developed within the part multiplied by the distance the part can deform. Designing flexibility into the part to lengthen the distance over which the energy is absorbed greatly reduces the internal force required to resist the impact. For example, a rigid base made from spring steel would not have as high a capacity for absorbing energy as a coil spring made from the same material. The same factors that affect metals also affect plastics. As more and more flexibility is designed into a part subject to impact load, the better the part will perform.

Teflon resins have excellent impact strength over a wide range of temperatures. Average values for specimens of Teflon subjected to the tensile-impact test and the Izod-impact test are given in Table 7.

There is no exact method for relating impact test data to actual design calculations or performance. Generally, in addition to incorporating flexibility, the most important method for obtaining toughness or impact resistance is to eliminate all sharp corners and other features subject to high stress concentration. For exact design, prototype models must be tested under actual loads.

Hardness: Table 8 lists the hardness of Teflon plastics as determined by various tests.

Friction: Teflon parts have a smooth surface with a slippery feel. This slipperiness is confirmed by test. Fig. 12 and 13 indicate that static friction of Teflon resins decreases with increase in load. Static coefficient of friction is also lower than the dynamic coefficient. This characteristic eliminates the problem of "stick-slip" in which higher breakaway friction causes undesirable vibration.

The *PV* values in Table 9 are comparatively low. However, bearing surfaces of reinforced TFE resins are several orders of magnitude better than unfilled TFE resins. Filled FEP resins also offer higher *PV* values and are good bearing candidates.

Abrasion and Wear: Parts fabricated from TFE resins have good wear properties and make excellent bearing surfaces for light loads at low rubbing velocities. Tables 10, 11, and 12 indicate abrasion resistance of fluorocarbon resins for various kinds of tests.

Under heavy loads and high rubbing velocities, reinforced TFE compositions have proved superior to unfilled compositions. It is to be expected that reinforced FEP resins would perform similarly.

Electrical Properties: Combined with mechanical strength and chemical and thermal resistance, the outstanding electrical properties of Teflon plastics make these materials valuable and versatile elec-

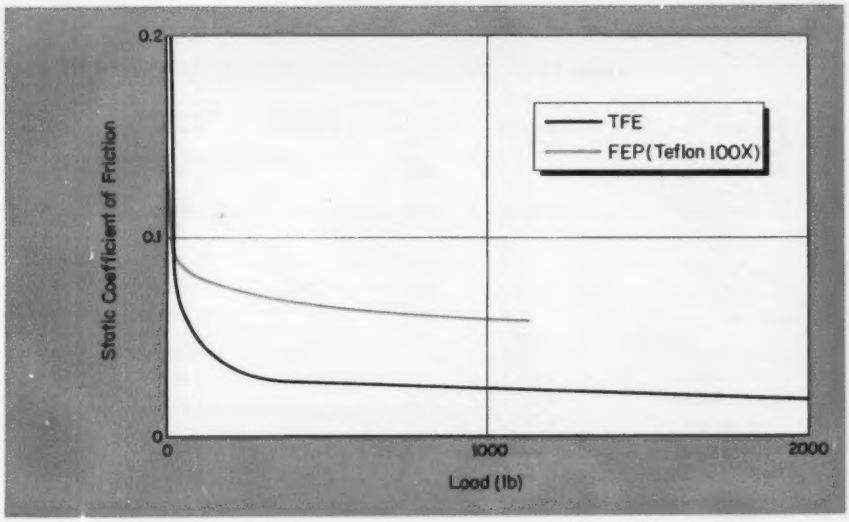


Fig. 12 — Static coefficient of friction versus load at 73 F. Curve for FEP resin was obtained for FEP on Elastuff A-2 steel having a surface finish of 5 to 6 microinches rms (worn surface).

trical insulators. As summarized in Table 13, TFE and FEP plastics have practically identical properties as electrical insulators when used within the recommended service temperature range. Teflon plastics have no water absorption, and volume resistivity values remain unchanged even after prolonged soaking in water. Surface-resistivity values were taken at 100 per cent relative humidity.

Dielectric constant for TFE plastics remains constant at 2.1 for a temperature range of −40 to 250 C and a frequency range of 5 cps to 10,000 megacycles. Dissipation factor is also constant at 0.0003 for the same ranges of temperature and frequency. After heat aging at 482 F, skived tape made from TFE resins has a dielectric constant of 1920 v per mil at the end of one month. The value drops to 1875 v per mil after 6 months. Comparable values for TFE spaghetti tubing are 1100 v per mil and 960 v per mil, respectively. The constancy of these factors is established by experience, and dielectric constant and dissipation factor are considered invariant over the range of useful service conditions.

Tests on FEP 100X over the frequency range of 100 cps to 50 megacycles and the temperature range of −40 to 250 C show its dielectric constant also invariant and identical to the values for TFE resins. A minor peak in the dissipation factor is noted at slightly above 1 megacycle, Table 14.

Teflon insulation has good arc resistance. When exposed to electrical arcing, Teflon surfaces experience some erosion. However, no carbon track is

Fig. 13—Kinetic coefficient of friction versus sliding speed at 73 F. Curve for FEP resin was obtained for FEP on Elastuff A-2 steel having a surface finish of 5 to 6 microinches rms.

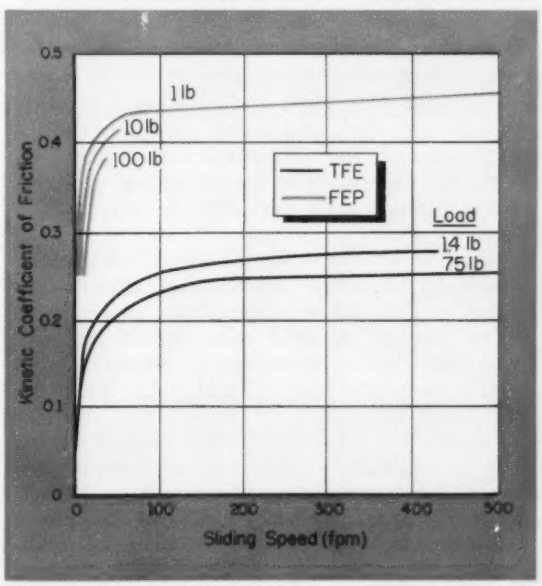


Table 13—Electrical Properties

Property	TFE	FEP (Teflon 100X)
Volume resistivity (ohm-cm)	$>10^{19}$	$>10^{19}$
Surface resistivity (ohm/sq)	$>10^{17}$	$>10^{17}$
Dielectric strength	See Fig. 14-17	
Dielectric constant		
60 cps to 60 megacycles	2.1	2.1
3000 megacycles	2.1	2.1
Dissipation factor		
60 cps to 60 megacycles	<0.0003	<0.0003
3000 megacycles	<0.0003	0.0006 (At 50 megacycles)
Arc resistance	Will not track	Will not track

Table 14—Effect of Frequency on Dissipation Factor of FEP Teflon 100X at 73 F

Frequency	Dissipation Factor
10^2 cps	0.0003
1 kc	0.0002
10 kc	0.0002
100 kc	0.0005
1 megacycle	0.0007
50 megacycles	0.0006

ASTM D 150-54 T.

Table 15—Typical Electrical Properties of Reinforced TFE Plastics

Material	Thickness (in.)	Dielectric Strength[1] (v/mil)	Dielectric Constant[2]	Dissipation Factor	Volume Resistivity[3] (ohm-cm)	Surface Resistivity[3] (ohm/sq)
Unfilled	0.07	400	2.1	0.0002	1.89×10^{19}	10^{17}
15% Milled glass fiber	0.05	250	2.4	0.0006	5.0×10^{14} (dry) 6.7×10^{8} (wet)	2.9×10^{13} (dry) 4.0×10^{12} (wet)
35% Milled glass fiber	0.05	230	2.8	0.0019	1.25×10^{15} (dry) 1.78×10^{8} (wet)	2.4×10^{13} (dry) 6.1×10^{12} (wet)
50% Quartz	—	—	3.65	0.008	—	—
15% Graphite	0.06	—	—	—	2.44×10^{6}	1×10^{5}
35% Graphite	0.06	—	—	—	2.44×10^{6}	1×10^{5}
15% Copper	0.06	—	—	—	2.44×10^{6}	1×10^{5}

[1]ASTM D 149-55 T. [2]ASTM D 150-54 T. [3]ASTM D 257-57 T.

formed, and the initial high surface resistivity is maintained.

Short-time dielectric strength values are high, Fig. 14, and are relatively unaffected by heat aging at 482 F as previously noted. Values range from 500 to 4000 v per mil depending on thickness. The effect of temperature on dielectric strength of TFE resins, Fig. 15, is negligible over the range from room temperature to the upper continuous operating temperature. Dielectric strength of TFE drops off less with increase of frequency, Fig. 16, than for other materials tested to date. At 100 megacycles, for example, dielectric strength is 130 v per mil—about six times that of glass at the same frequency.

Insulation systems in continuous service, Fig. 17, are used at stresses well below the short-term dielectric strength because of the damaging effects of corona bombardment. TFE resins are unaffected by ozone and ultraviolet light which accompany corona but, like other relatively soft organic insulations, are eroded by ionized molecules. Therefore, recommended working stresses are normally 50 to 100 v per mil, which are typical values for design of equipment operating below 2300 v.

Reinforced TFE resins have increased dielectric constant and dissipation factor and decreased dielectric strength and volume and surface resistivity, Table 15. Depending on the reinforcing agent, arc resistance may remain unchanged or be reduced.

Miscellaneous Properties: Tests of TFE samples exposed for 12 years to practically all climatic conditions confirm the weather-resistant properties of Teflon plastics. An FEP resin exposed for three years also showed no change in properties. Resistance to extreme heat and cold and to ultraviolet light is excellent.

Permeability of molded Teflon sheet is comparable to neoprene and butyl rubber. The combination of low permeability and chemical resistance makes Teflon an excellent material for lining pipe and equipment used under severe corrosive conditions at temperatures up to 400 or 500 F.

Vibration-damping properties of Teflon plastics are excellent at both sonic and ultrasonic frequencies. Sufficient material thickness to absorb the energy produced is usually determined experimentally.

Reinforced Compositions: Fillers are used in TFE resins to improve their performance. While retaining the desirable properties of uncompounded resins, modified compositions meet the requirements of an increased variety of mechanical, electrical, and chemical applications. Various properties and the approximate amount of increase obtained with compounded TFE resins are:

1. Resistance to initial deformation under load—25 per cent.
2. Resistance to rotating shaft wear—500 times.
3. Stiffness—2 to 3 times.
4. Thermal conductivity—5 times.
5. Resistance to creep—2 times.
6. Thermal dimensional stability—2 times.
7. Hardness—10 per cent.

Although extensive information is available for reinforced TFE*, little has been done with reinforced FEP resin because of its newness. However, reinforcing Teflon 100X should improve the properties of this FEP resin as it has for TFE resins.

Methods of Fabrication: Teflon 100X FEP resin melts and flows, while TFE resins do not. Consequently, TFE resins require fabricating techniques somewhat different than those used with other plastics.

Because FEP resin is thermoplastic in the conventional sense, many processing conditions used with TFE resins do not apply. Preforming pressure, sintering time, cooling rate, void content, and crystallinity level, all of which are important in processing TFE, are not usually considered when processing FEP. Important factors in processing FEP are that the resin not be degraded and that the fabri-

*F. M. Chapman—"Reinforced Teflon," MACHINE DESIGN, Vol. 30, No. 19, September 18, 1958, p. 148.

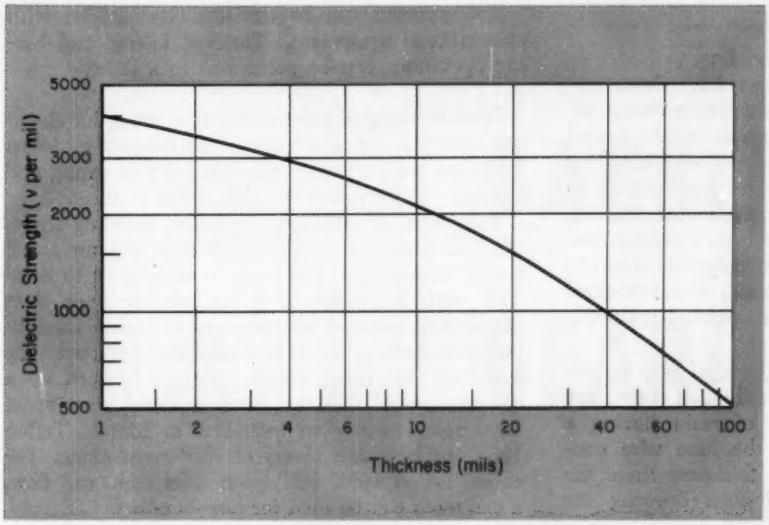


Fig. 14 — Dielectric strength versus thickness for short-time test at 60 cps.

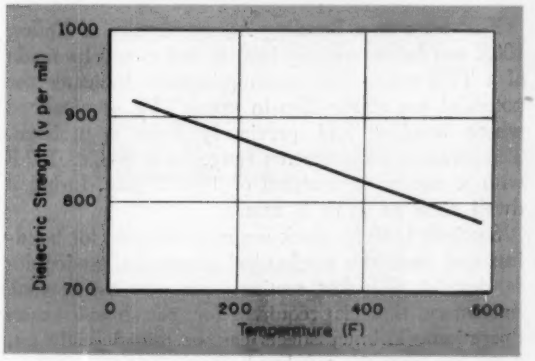


Fig. 15—Short-time test of dielectric strength as temperature varies. (ASTM D 149-55 T, 1-in. electrode in silicone oil.)

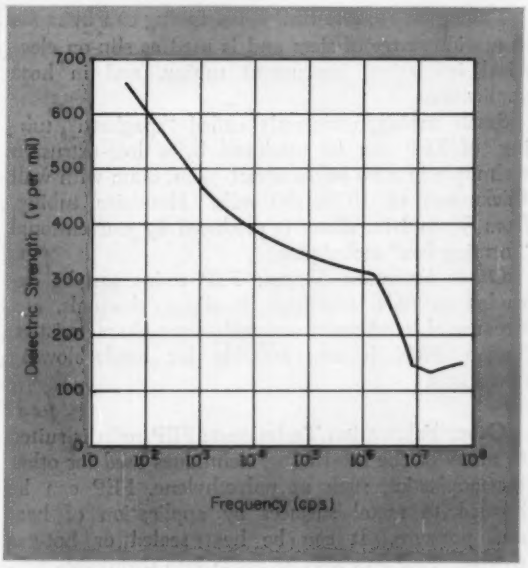


Fig. 16—Effect of frequency on dielectric strength of TFE in oil. (1/16-in. breakdown path, ¾-in. diam electrode with ⅛-in. edge radius, 40-sec test.)

cated part have a good surface and a homogeneous structure. Beyond this, most properties are relatively insensitive to processing conditions.

Any injection-molding machine of standard design, properly sized for the job, can be used for molding FEP resin. Depending on thickness of the part, 30 to 60 mils per in. shrinkage is allowed in molds for noncritical parts. When accurate dimensions are required, a test cavity should be used to determine exact shrinkage allowances.

Because usual service temperatures for FEP plastics are equal to or lower than temperatures used during molding, few dimensional changes result from stress relieving. Molded parts show little change in room-temperature dimensions after prolonged exposure in air at 450 F.

Dry blending is a simple and economical way of adding pigments to FEP 100X prior to molding. Of course, only pigments stable at molding temperatures should be used.

Conventional melt-extrusion equipment is also used in processing FEP resins. Commercially available pigments can be mixed with the resin before

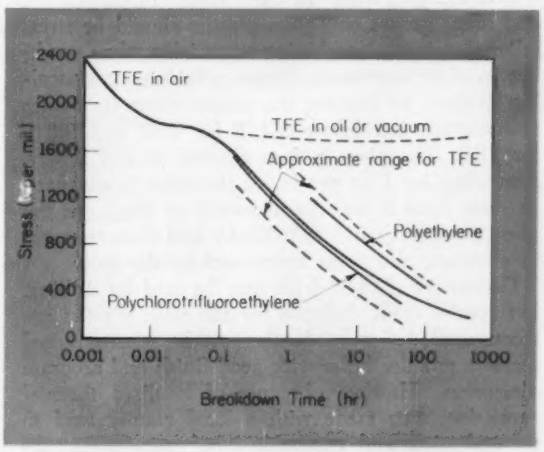


Fig. 17—Life versus continuously applied voltage stress. (ASTM D 149-44, ¼-in. brass electrodes, 5 to 6-mil specimens.)

extrusion as is done prior to molding.

Wire Coating: No restrictions have been encountered on the type of conductor, primary insulation, or jacketing material which can be coated with Teflon 100X. Also, with proper wire handling equipment, no limits have been apparent as to diameter or shape of the core to be coated. Coating thicknesses of 3 to 30 mils have been extruded over such materials as silicone rubber, polyvinyl chloride, neoprene, TFE resins, glass braid, metal-shielded cables, twisted conductors, and parallel-multiconductor cables.

When extruding Teflon 100X as a primary insulation or cable jacket, high production rates are achieved by extruding a tube of resin having a larger internal diameter than the base wire construction and a heavier wall thickness than the final insulation thickness, and then drawing the large tube down to desired size.

Tubing Extrusion: FEP 100X tubing can be made in a wide range of sizes and is used as slip-on electrical insulation, instrument tubing, and in hose applications.

Small tubing, commonly called "spaghetti" tubing, of FEP can be produced by a free-extrusion technique in sizes below about ⅜-in. diam with wall thicknesses of 10 to 30 mils. Hose-size tubing, from ⅜ to 1-in. diam, is produced by conventional "forming box" techniques.

Other Extrusion Shapes: FEP resins can be extruded as rods, moldings, beadings, channels, etc. Because of its viscosity and melt-draw characteristics, Teflon 100X is also suitable for bottle-blowing operations.

Other Fabrication Techniques: FEP resin is suited to many of the fabricating techniques used for other thermoplastics, such as polyethylene. FEP can be bonded to metal surfaces by application of heat and pressure. It can be heat sealed or hot-gas welded. FEP can also be made into shrinkable tubing used for coating and is suited to extrusion laminating.

Machining Teflon Resins: Rods, tubes, billets, and other shapes of Teflon plastics should be stress relieved prior to machining, especially when working to close tolerances. Stress relieving, or annealing, is done by heating the plastic above its service temperature, but below 621 F for TFE and 500 F for FEP. The piece is then allowed to cool slowly. Annealing for 1 hr per in. of thickness is adequate. In some cases it may be necessary to rough-cut the piece to within 0.015 to 0.030-in. and then reanneal to eliminate the stress introduced by the tool.

Conventional twist drills may be used for drilling, but special drills designed for use with plastics are recommended for production work. Conventional reamers produce holes with good finish and accurate dimension. However, because of localized thermal expansion, cuts made with a fixed reamer tend to be undersize, and expansion-type reamers may be preferred.

Teflon resins can be threaded and tapped with conventional equipment. Turning, facing, and boring operations can be performed in a lathe.

Heat-Bonding of Joints: The best lining for chemical equipment is obtained by heat-bonding all joints of Teflon resin sheets. Such joints are as strong and resistant to corrosion as the original sheet.

Because of its antistick properties, bonding sheets of TFE plastic to itself is difficult without using special techniques. Moreover, it is difficult to bond TFE with a hot-gas torch because the resin does not flow at elevated temperatures like other thermoplastic materials. Some of these limitations are now overcome by using simple contact heaters at a temperature of 650 to 700 F to bond sections of sheet stock having an interlayer or film of Teflon 100X, or by using sheets of FEP resin alone. Because Teflon 100X FEP resin does melt and flow, a gas torch can be used for heat-bonding.

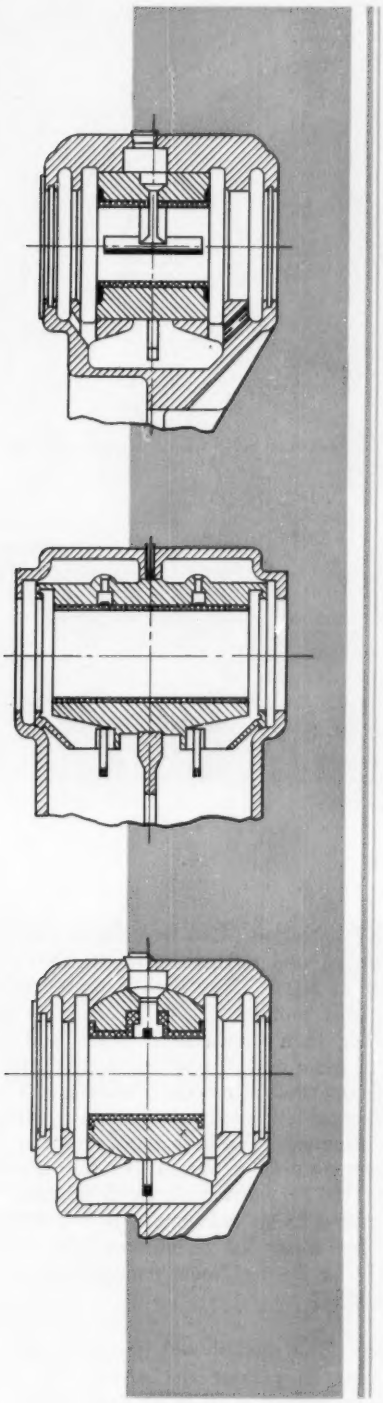
FEP Film as a Bonding Agent: A film of Teflon 100X can be successfully heat-sealed to articles made of a TFE resin. This accomplishment indicates the potential use of the film in many TFE applications where bonding had previously been a problem. Temperature requirements range from 650 to 700 F with a necessary pressure of 1 to 2 psig during a dwell time of 1 to 2 min.

Sections 1/16-in. thick are most suitable for bonding and have the mechanical properties needed for fabrication. Thicker sections can also be bonded, but more time is required for the heat-transfer operation. Thinner sheets can be joined easily but have less strength to absorb thermal stresses. Consequently, more care is required during the bonding operation to prevent permanent deformation of the joint. All sheet stock of TFE plastic to be bonded should be stress-relieved for 2 hr at a temperature 90 F above the maximum service temperature.

Cementable Surfaces: Various procedures have been developed for preparing special surfaces on TFE and FEP parts to which conventional adhesives will bond. As a result, good bonding strength is achieved with adhesives in bonding to wood, glass, steel, aluminum, copper, ceramics, plastics and, in fact, any material that will bond with an adhesive. This development permits new applications for TFE and FEP where materials with antistick and frictional properties are required at elevated temperatures and under severe corrosive conditions. Although parts fabricated of TFE and FEP will withstand high temperatures, maximum temperature of the adhesive may limit the application and should be established first.

Curves for FEP

In "New Design Data for FEP and TFE," page 136, January 21 issue, color curves for FEP in Fig. 9*a* are for 212 F; color curves in Fig. 9*b* are for 73 F.



BABBITT BEARINGS

. . . producibility factors that determine top performance and reliable service

F. E. BLACK
DC Motor and Generator Engineering
Large Rotating Apparatus Dept.
Westinghouse Electric Corp.
East Pittsburgh, Pa.

BABBITT metal, composed of tin and lead, is an old and well-known bearing metal. But it still best fulfills seven important requirements of an efficient bearing material:

1. Antifriction properties.
2. Seizure resistance.
3. Conformability.
4. Fatigue strength.
5. Corrosion resistance.
6. Bondability.
7. Ability to be repaired readily.

In early babbitt bearings, the babbitt was anchored to the bearing shell by mechanical means, such as dovetailing and drilling. To provide better bonding, many chemical and plating methods have been used. The latest is an electrochemical means of bonding.

The process of producing a babbitt bearing in-

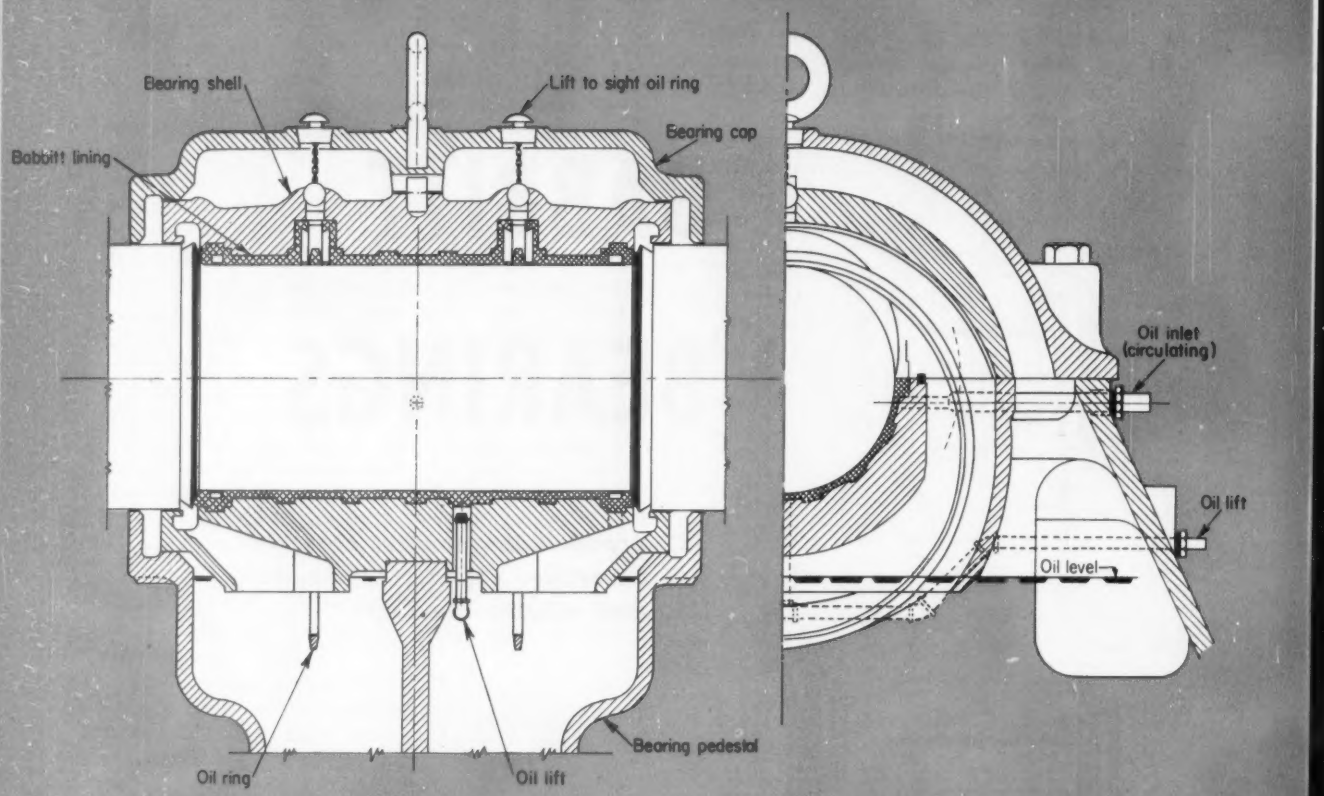


Fig. 1—Design details of babbitt bearing assemblies.

volves selection of bearing composition, shell surface preparation, tinning, and babbitting.

Bearing Composition: In applications for high-speed service, high bearing loads, and high-impact service, alloys with high tin content are used. Babbitt with high lead content has better embedding and conforming characteristics, good antifriction qualities, and is less expensive, but is not as good as high tin-content babbitts for impact service.

Several elements are used to provide the babbitt with characteristics desired for a particular application, Table 1. Careful selection of elements results in bearings that can be employed for special applications.

Surface Preparation—Steel Shells: All bearings are tinned with a lead-tin solder before the babbitt is poured. A chemically clean surface is necessary for effective tinning. With a steel shell, this may be accomplished by machining a fine cut into the shell surface and tinning while the surface is clean. Where this is not done, a pickling process produces a good bonding surface. Soaking for 5 minutes in a 10 per cent hydrochloric acid solution should produce a surface of iron or ferrite for reaction.

Surface Preparation—Cast-Iron Shells: The Kolene process can be used to clean cast-iron shells electrochemically at 500 C. The shell is heated to 400 C prior to bath immersion. Bath operation is one of oxidation, then reduction of scale, and finally removal of gases and oils by an electrochemical.

The electrochemical process is completed through a reduction-oxidation-reduction cycle. Then the shell is immersed in cold agitated running water (room temperature) momentarily, and transferred to a hot (180 F) water bath for 5 minutes. The shell is moved to an acid bath for 4 minutes and back to hot water for 5 minutes. Bearings are then ready for fluxing (room temperature) and are tinned at 325 C.

Tinning: The shell should be fluxed with zinc-chloride flux to prepare the surface for tinning. The tinning bath is a 60-40 tin-lead solder. This bath coats the surface and raises the bearing shell temperature. If the bearing is too large to fit in the bath, a 40-60 stick solder can be used to prepare the bonding surface. In all cases, the bearing shell should be heated to about 300 C.

Babbitting: When babbitt is melted for pouring,

Table 1—How Elements Affect Babbitt Alloy Characteristics

Tin: Toughens the alloy, lowers the melting point, and resists corrosion. Lacks antifriction qualities compared to lead and tends to heat quickly and fuse.

Lead: Softens the alloy, has good antifriction qualities.

Copper: Hardens and toughens the alloy in the presence of tin, raises the melting point, and increases friction.

Antimony: Hardens the alloy at the expense of ductility, raises the melting point, reduces friction, and is resistant to corrosion. Segregation of antimony in the babbitt alloy must be prevented.

Silver: When added to lead-base alloys, improves retention of hardness at elevated temperatures and improves bondability.

overheating must be prevented or excessive oxidation and drossing occurs. If the dross is poured with the metal, excessive porosity results. Normal pouring temperature for the two babbitt materials most commonly used—high lead-base and high tin-base—is 475 C.

When a high lead-base babbitt is poured into the shell, lead mixes with the lead-tin interface preparation which may result in a poor bond. Maintenance of correct temperatures and correct surface preparations will insure satisfactory bonding. With a high tin-base babbitt, proper surface preparation allows for a slight variation, since the tin of the poured babbitt dilutes the interface.

There are several ways of babbitting the shell. Two methods commonly used are static (horizontal and vertical) and centrifugal.

The centrifugal method is used mainly for smaller bearings, 6-in. bore diameter or less. The shell is at 325 C when placed in the spinning machine. After pouring, cooling water is directed at the outside of the bearing shell, and the shell is cooled to not less than 300 F. Cooling too fast causes thermal shock which can break the bond between shell and bearing babbitt.

Two more recent babbitting methods are metal-spray babbitting and diffusion bonding. An excess of oxide results from the metal-spray method. In the diffusion-bonding method, the babbitt form is cast and placed in the metal shell. Pressure is placed on the babbitt and the assembly is held at 160 F for a 24-hr period. This forces the babbitt to conform to the shell and gives a weak, mechanical bonding between the shell and babbitt.

Several testing methods are used to determine the babbitt's condition and its bonding to the shell. To check surface porosity, a fluorescent penetrant-type oil is used to wet the surface. After the oil soaks into the pores, the excess is removed and a special powder is dusted on the surface. Oil in the pores adsorbs to the powder and black light causes the oil to "glow." Thus, pores are detected. The reflectoscope tests the bearing ultrasonically to determine bonding between babbitt and shell metal.

Tips and Techniques

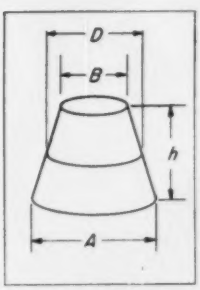
Cone Frustum Volume

Calculation of the volume of a frustum of a cone is simplified by the use of the following formula:

$$V = 4DCh$$

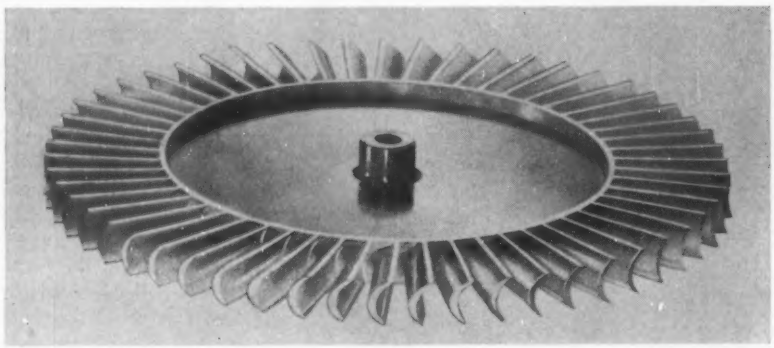
where mean diameter $D = \frac{1}{2}(A + B)$ and C is a coefficient from the following table.

A/B	C	A/B	C	A/B	C
1.1	1.0007	1.7	1.022	3.5	1.103
1.2	1.003	1.8	1.027	4.0	1.120
1.3	1.006	1.9	1.032	5.0	1.148
1.4	1.009	2.0	1.037	7.0	1.187
1.5	1.013	2.5	1.061	10	1.223
1.6	1.018	3.0	1.083	20	1.273



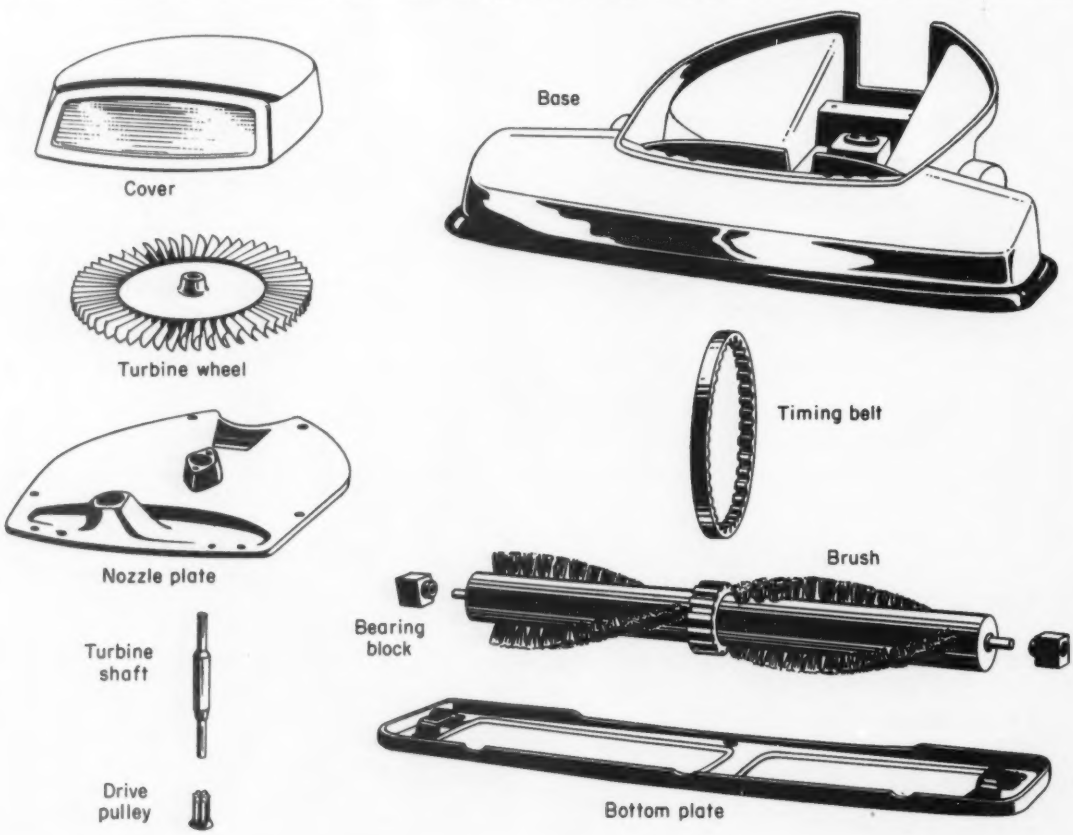
—Kazimierz Prugar, *Middlesbrough, England.*

Air Turbine Powers Rotary Brush

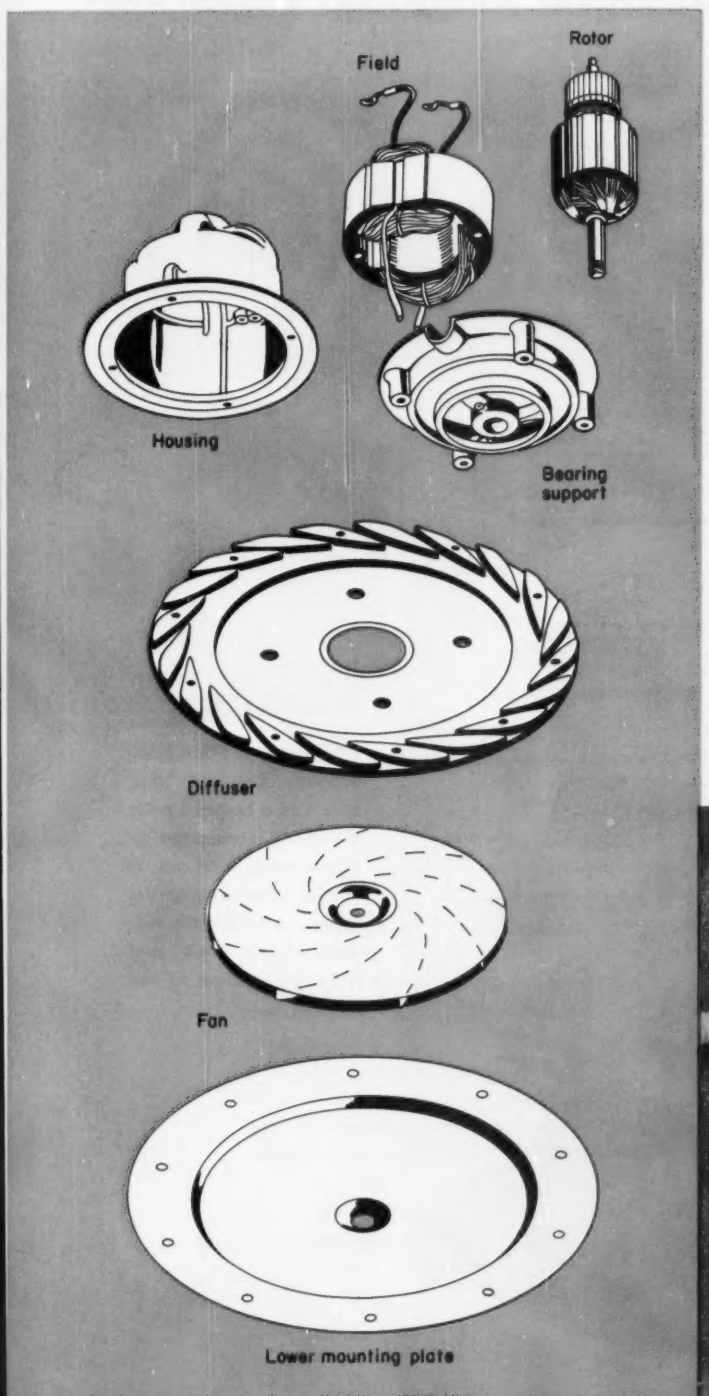


POWER TO DRIVE the rotary brush in this vacuum cleaner is delivered through a lightweight turbine fan in the sweeping unit. Nylon turbine wheel with 56 curved buckets is injection molded in one piece. Low profile, designed for maximum clearance under furniture, is aided by flat configuration of fan.

POWER IS TRANSMITTED from turbine by a timing belt that drives the brush. Brush wear is compensated by bearing blocks which revolve to adjust height of mounting.



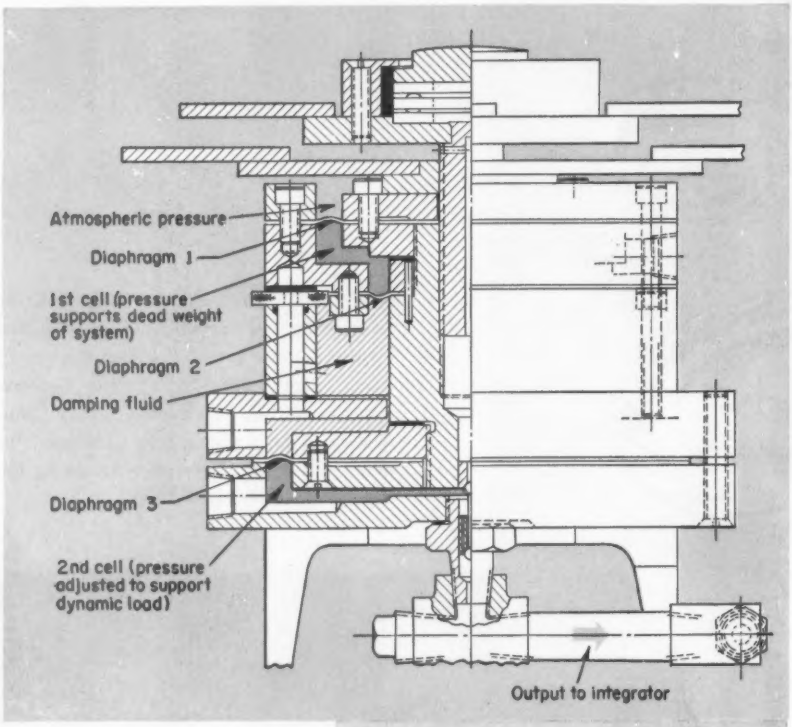
In Lightweight Tank Sweeper



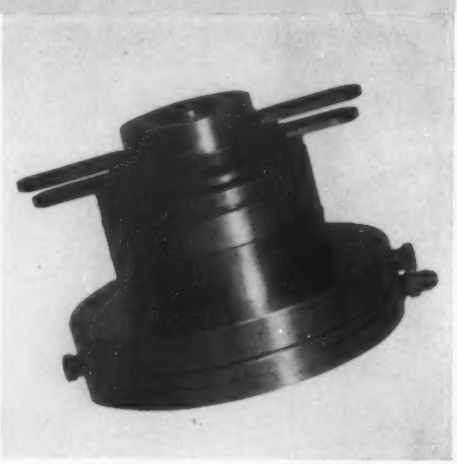
AIR TO DRIVE the turbine is drawn by a 1.5-hp electric motor housed in the tank. Its centrifugal fan creates enough suction to support a 70-in. column of water.

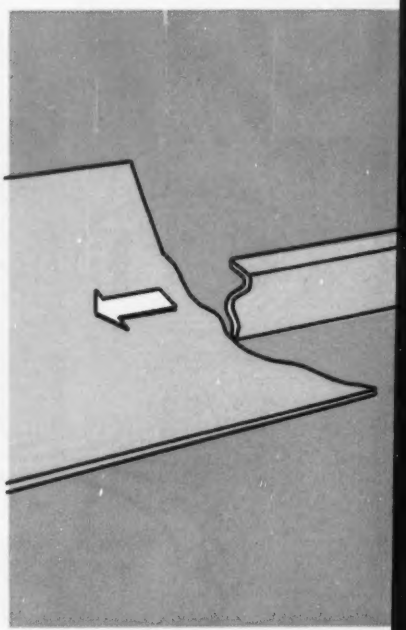
LOW CLUTTERED profile of both tank and sweeper units is accomplished by using short vertical shafts with large-diameter rotors. Result is large capacity with low clearance requirement. Vacuum cleaner is Dual Deluxe developed by Sunbeam Corp., Chicago. Turbine molding problems were solved by Chicago Molded Products Corp.

Mechanical Computer Integrates



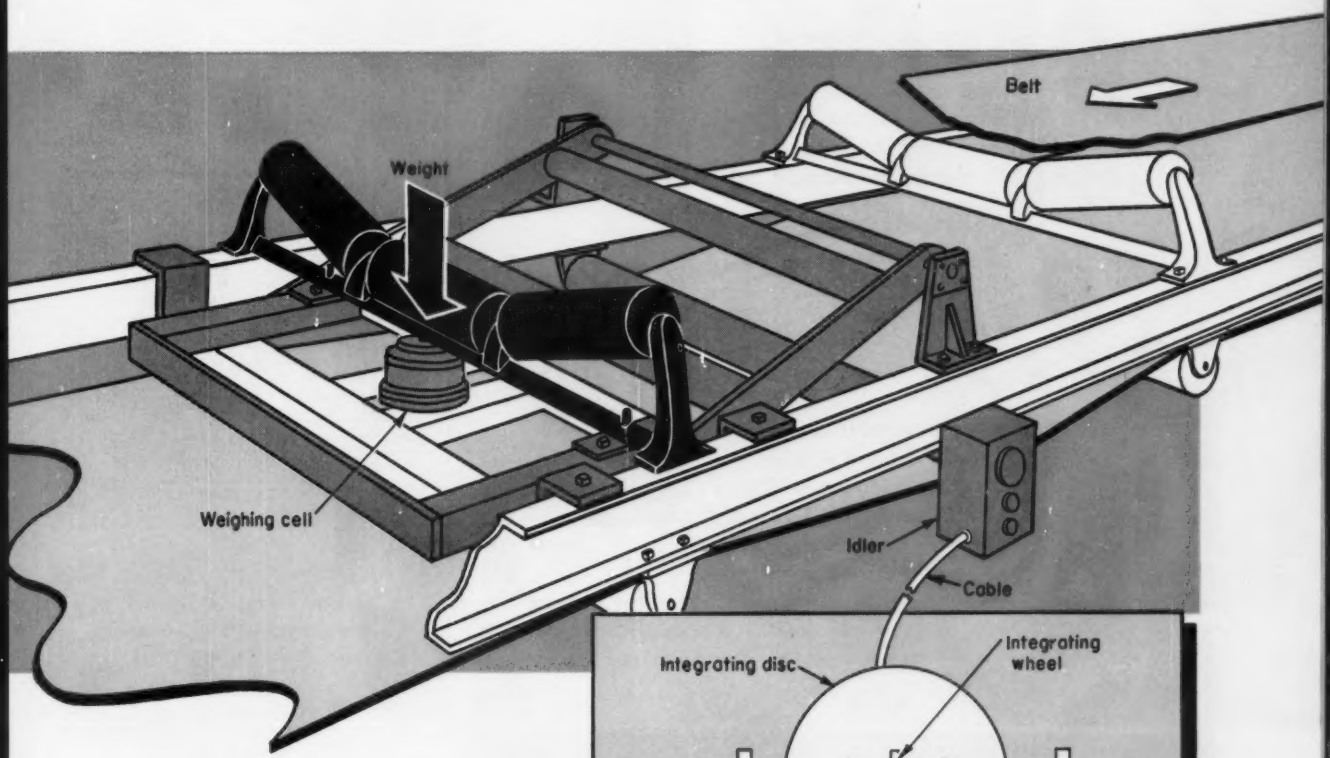
TWO-CELL WEIGHING UNIT separates live and dead weight. Only live-weight pneumatic signal (lower cell) is sent to integrator. Continuous weighing system was developed by B-I-F Industries, Providence, R. I.

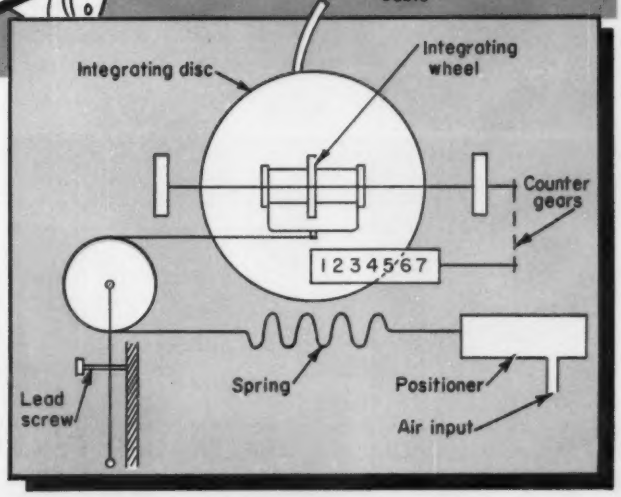




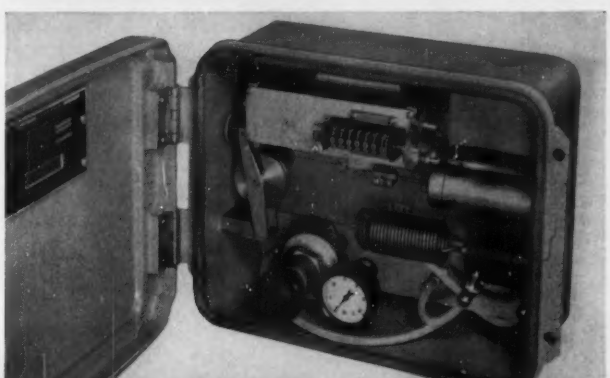
WEIGHING STRUCTURE supports standard idler rollers on a hinged frame. Weight is transmitted to a pneumatic load cell. A special idler beneath the frame turns with the motion of the belt and transmits rotation to the flexible cable.

Variables In Continuous Weigher



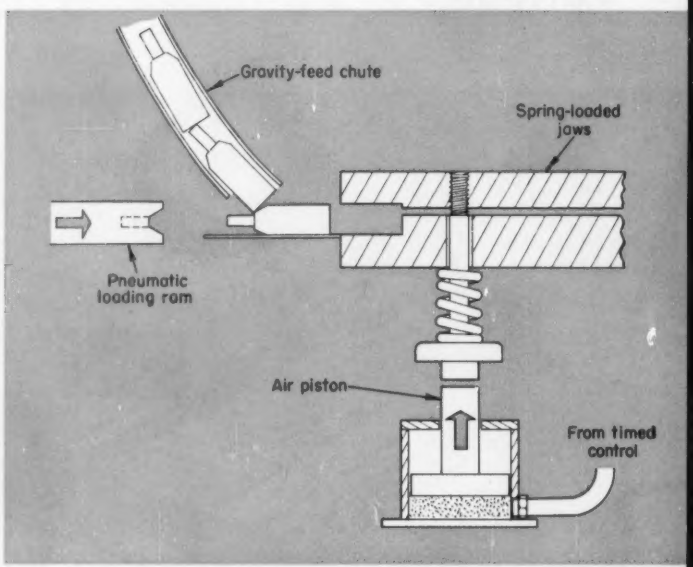


WHEEL-AND-DISC integrator relates conveyor belt load with speed for a continuous running total of load carried. Flexible-cable coupling at the back (not shown) transmits rotation, corresponding to belt travel, to the disc. Pneumatic-pressure input, corresponding to net weight on belt, moves the wheel across the disc. Zero adjustment can be made with lead screw.

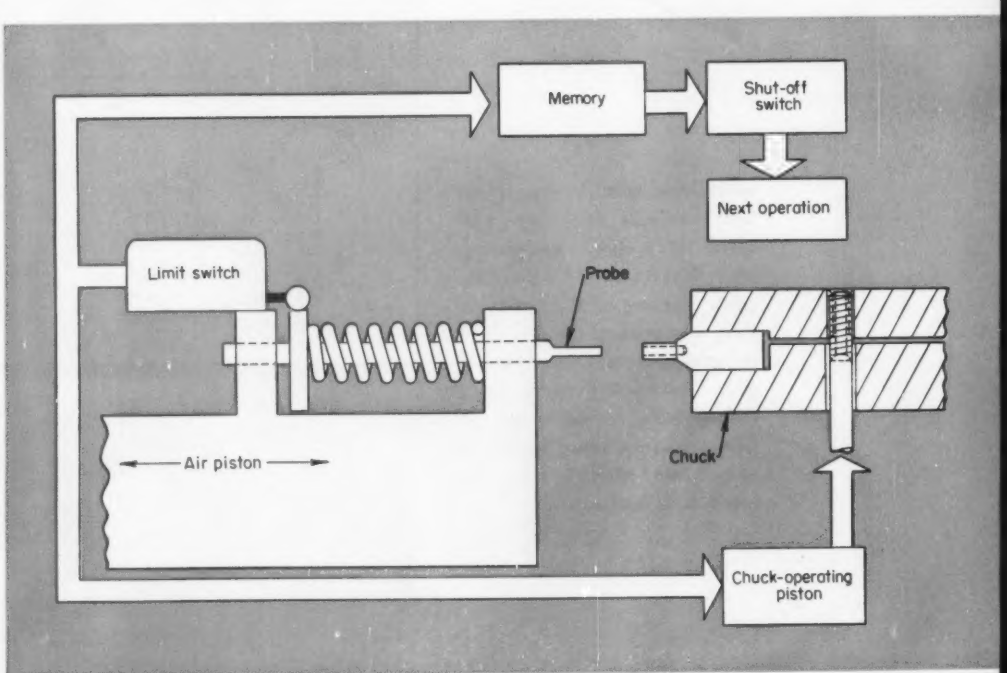


Air Piston Operates Chuck

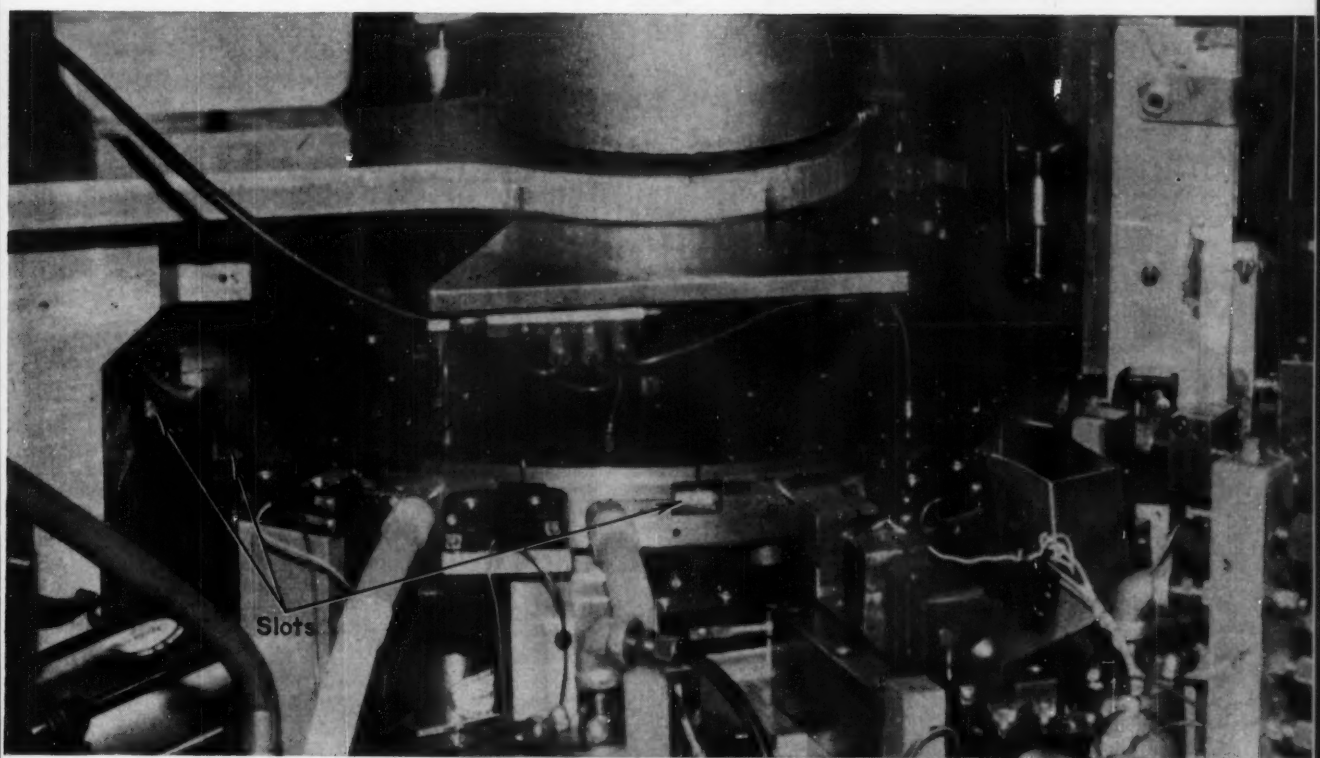
SPRING-LOADED SLOT in rotary table holds workpieces to be operated on by multiple-operation automatic assembler. Air from a timed control actuates a piston to press open the edges of the slot as a pneumatic loading ram drives in the properly oriented piece at the bottom of the feed chute.



INSPECTION PROBE checks blank for presence of hole vital to succeeding operations. Absence of hole trips limit switch, actuating rejection mechanism and alerting a memory unit which shuts down each subsequent operation for one cycle as this slot passes its station. Too tight of a fit compresses the spring during attempted withdrawal with the same result.

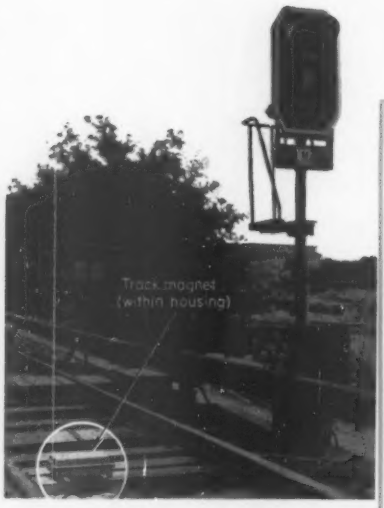


To Load Parts Automatically



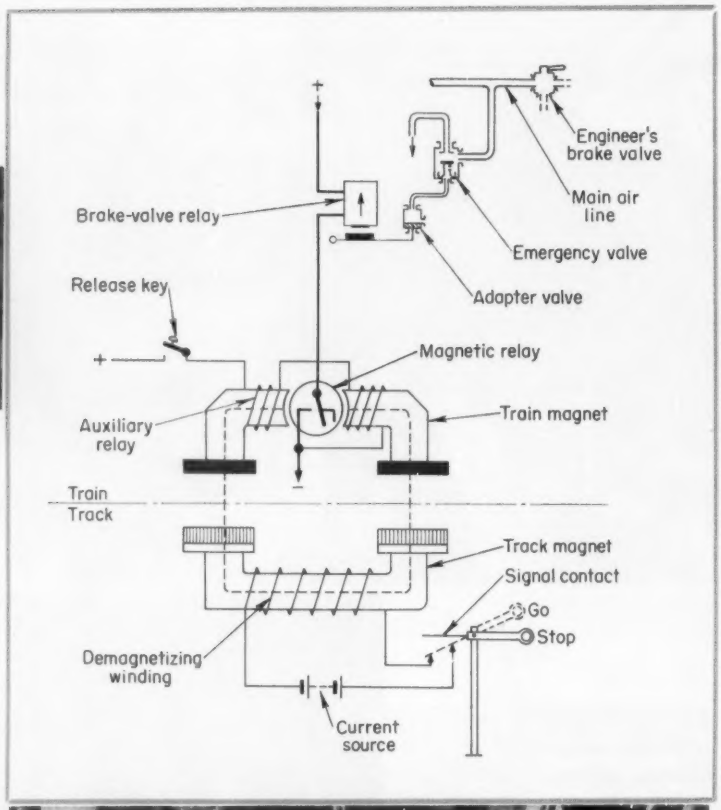
ELEVEN OPERATIONS are performed on a miniature electrical connector socket by the automatic machine. These include standard milling, drilling, and assembly operations as well as three inspection stations similar to the one shown. The socket-making machine was developed by Consolidated Electrodynamics Corp., Pasadena, Calif.

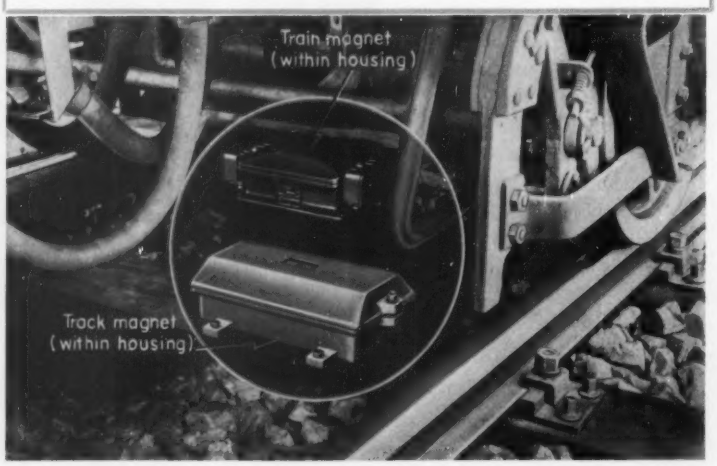
Permanent Magnet in Track Bed Automatically Trips Train Brakes



HEEDLESS ENGINEERS ARE DOUBLE-CHECKED at train signals by a magnet in the track bed that trips the train brakes if the train overruns a stop sign. Normally, the permanent-magnet flux in the track magnet is neutralized by an electric coil which is energized as long as the "green light" is on. Electric power failure automatically stops the train.

RELEASE KEY IS PROVIDED to energize an alternate neutralizing coil in the train and release the brakes, permitting the aroused engineer to put the train in motion when the danger is passed.



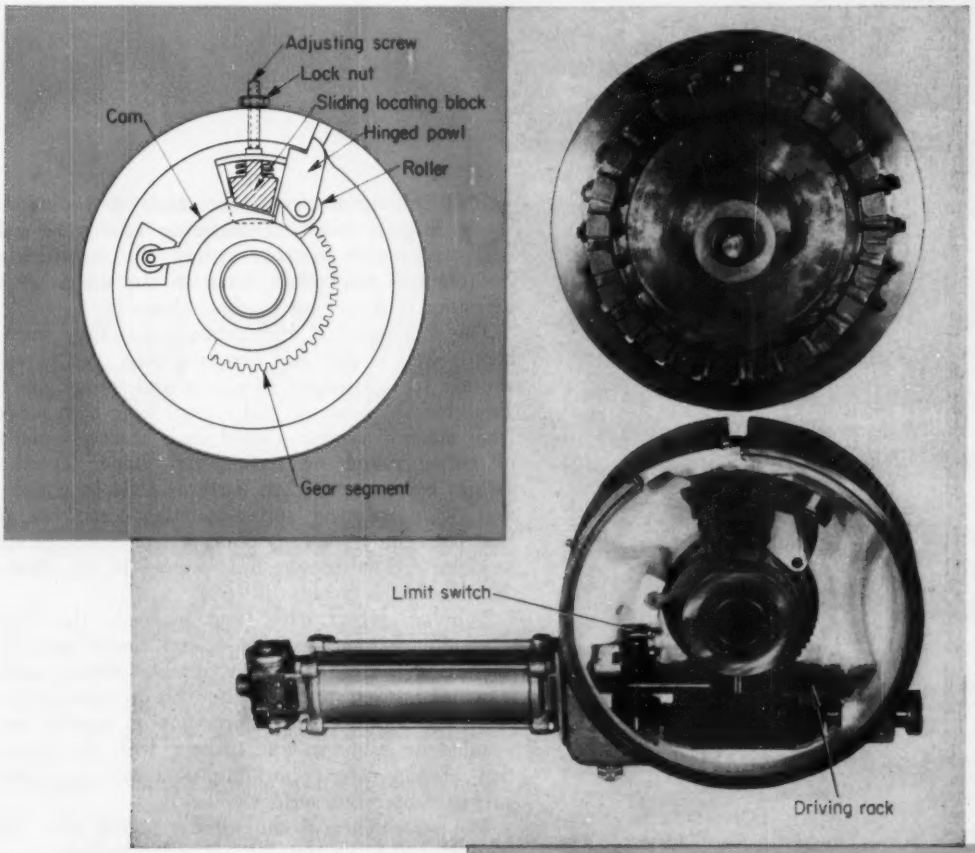


Permanent-magnet train brake controls developed by Siemens & Halske AG, Erlangen, Germany, are said to be simpler than induction-type controls presently used on German railroads.

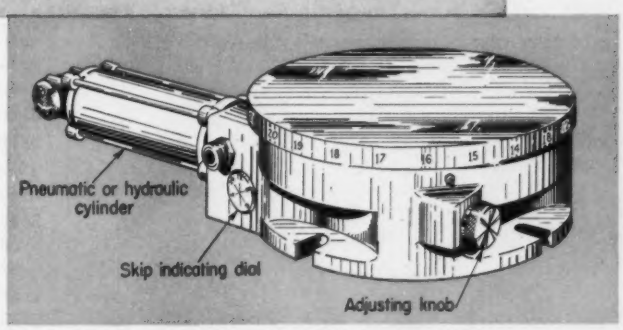
Screws Change Angular Location of Stations On Versatile Indexing Table

CAM AND BLOCK arrangement stops turntable at point predetermined by screw setting in a unique indexing table. The block, turning with the gear segment, slides over the cam's involute surface until its outward progress is blocked by the screw. Wedging of the cam stops forward motion at this point. Adjustment of screws provided at each station allows 15 degrees variation in the position of any of the 24 stations.

Developers of the Versi-Table, Savage Engineering Div., The Lithbar Co., Holland, Mich., have applied for a patent on it. The table is made in sizes from 12 to 48 in. diam. Larger sizes with more stations are possible if required.



DRIVING FORCE for the indexing motion is furnished by a hydraulic or pneumatic cylinder through a rack and gear segment. Its stroke can be lengthened to skip one, two, three, or five stations for a regular pattern of 12, 8, 6, or 4 work positions. A limit switch reverses action at the end of the recovery stroke, and its position determines the length of stroke. An external adjusting knob moves the limit switch.



Designing

Tubular Coil

A new kind of coil spring has been introduced recently. This spring uses round tubing instead of solid wire or bar. Thus, it is called a tubular coil spring. This article presents data and formulas for design of this new type of spring, and discusses its application possibilities and limitations relative to other types of springs.

CHARLES W. BERT
Dept. of Engineering Mechanics
Ohio State University
Columbus, Ohio

GREAT strides have been made in the metallurgical and manufacturing aspects of coil springs in the past century. But surprisingly few changes have been made in the design configuration of these basic machine elements.

The weight-saving characteristic of tubular members is well known and has long been used to advantage in lightweight structures and torque tubes. Traditionally, however, coil springs have been made from material having a solid cross section, usually of either round or rectangular shape. Tubular springs were suggested as early as 1884 in connection with reducing spring-material costs; but it has been only recently that the ever-increasing need for lighter weight has resulted in the development of such springs.

Tubular springs have been made in the form of compression springs,[1] Fig. 1, and torsion springs.[2] Since compression loading is the most widely used, it will be given primary attention in this article. However, most of the information is equally applicable to extension-type springs, with the exception of the column-buckling data which applies only to compression springs.

The advantages of the tubular spring over the conventional solid cross-section spring include:

1. Lighter weight for the same load-carrying capacity, spring rate, or energy-storage capacity.
2. Faster release velocity.
3. Higher natural frequency.
4. Better resistance to high temperatures when internally cooled by a liquid coolant.
5. Greater utility in design; it can be used as a means of supplying hydraulic fluid for lubrication, actuation, or cooling of the machine supported by the spring or springs.

[1]References are tabulated at end of article.

Springs

As with most machine elements, tubular springs also have some inherent drawbacks which limit their use in certain applications. These disadvantages, as compared to solid cross-section springs, are:

1. Larger space requirement for the same load-carrying capacity, spring rate, or energy-storage capacity.
2. Higher initial cost due to higher cost of material in tubular form and added difficulty in coiling.
3. Greater susceptibility to torsional crippling (local buckling).

Stresses: Results of a detailed stress analysis,[1] based on the theory of elasticity and checked experimentally, are given in Fig. 2 for the two extreme values of the ratio of inside to outside diameter of the tubing: $B = 0$ (solid) and $B = 1$ (thin wall). These plots show the maximum shear-stress factor, which is the ratio of the maximum shear stress in a concentrically loaded spring with zero helix angle to the nominal torsional stress in such a spring. The point of maximum stress is shown in Fig. 1.

Nominal stress in a tubular spring is (see Nomenclature):

$$S_{nom} = \frac{8PD}{\pi d^3(1 - B^4)} \qquad (1)$$

Note that this equation is different from the familiar expression used with solid springs. As can be seen from Fig. 2, there is very little difference between the curves for $B = 0$ and for $B = 1$. This result means that there is very little interaction between the effects of coil curvature (spring index) and the hole in the spring. For comparison, Fig. 2 also gives the familiar Wahl factor, which is widely used in the design of solid-section springs. Note that the Wahl-factor curve lies closer to the curve

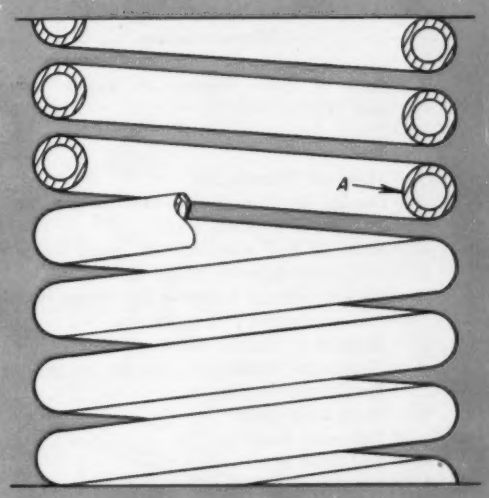


Fig. 1—Cutaway view of a typical compression-type tubular spring: Spring index $C = 6.9$, ratio of tube ID to tube OD = 0.70, and total number of coils = 6. Highest stress in the cross section is developed at point *A*.

for $B = 1$ than to the one for $B = 0$. Thus, for most purposes, the Wahl factor can be used for tubular springs with only a small error which is on the conservative side.

For all axially loaded coil springs regardless of whether they have solid or tubular cross sections, two other factors should be considered in estimating the strength of the spring: 1. Effect of load eccentricity on shear stress. 2. Effect of spring pitch (helix angle) on the maximum combined shear stress, including bending stress.

The effect of load eccentricity may be accounted for by multiplying the calculated shear stress by the factor, $1 + e$, where e is the ratio of the load eccentricity to the mean coil radius. For actual compression-type springs in which the ends are slightly nonparallel, this eccentricity ratio can be as high as 0.15.

The effect of spring pitch is to introduce a small compressive bending stress at the inside of the coil (point A in Fig. 1) where the shear stress is a maximum.[3] When this bending stress is combined with the shear stress by the usual method, it will be found that the shear-stress factor corresponding to the maximum combined shear stress is larger than the uncombined shear-stress factor by the value $p^2/2$. Since the maximum stress is developed in a compression-type spring when the helix angle is smallest, this correction may be neglected in many practical cases involving compression springs.

For instance, for a compression spring with a spring index of only 3 (which is a much smaller value than should be used in a good design) and a minimum coil clearance of 20 per cent of its section diameter, the pitch effect increases the shear-stress factor only 0.8 per cent. For larger spring indexes and smaller clearances, the effect would be even smaller.

In summary, the maximum combined shear stress in a tubular spring can be calculated from

$$S_{max} = \left[K(1 + e) + \frac{p^2}{2} \right] \frac{8PD}{\pi d_3(1 - B^4)} \qquad (2)$$

Deflection: In the theoretical and experimental investigation mentioned previously,[1] it was also shown that axial deflection of a tubular spring, including effect of spring pitch, can be expressed as

$$F = \frac{8K_F P D^3 N}{G d^4(1 - B^4)} \qquad (3)$$

where the deflection factor, K_F, is given by

$$K_F = 1 - \frac{3}{16C^2} + \frac{3B^2}{8C^2} + 1.27\,p^2 \qquad (4)$$

when Poisson's ratio is 0.30.

In solid-section spring design, it is customary to use a deflection factor, $K_F = 1$, since the loss of accuracy due to this approximation is usually less than the uncertainty in the value of the modulus of rigidity of the material. Equation 4 shows that the deflection factor for any tubular spring ($B > 0$) is always greater than that of a solid spring ($B = 0$) having the same spring index and pitch. Thus, the practice of using a value of unity for the deflection factor may not always be justified for tubular springs.

Column Buckling: From the results of theoretical and experimental studies on the lateral buckling of solid-section compression springs by Haringx,[4] it can be shown that the critical column-buckling load of a tubular compression spring can be estimated by

$$P_{cr} = \frac{P}{F}\,\frac{F_{cr}}{H}\,H \qquad (5)$$

where P/F is the spring rate. From Equation 3, for $K_F = 1$,

$$\frac{P}{F} = \frac{G d^4(1 - B^4)}{8D^3 N} \qquad (6)$$

Fig. 3 gives a plot of F_{cr}/H as a function of ratio

Nomenclature

- B = Ratio of inside diameter to outside diameter of tube cross section
- C = Spring index = D/d
- D = Mean coil diameter, in.
- d = Outside diameter of tube cross section, in.
- E = Modulus of elasticity, psi
- e = Ratio of load eccentricity to mean radius of coil
- F = Total axial deflection of spring, in.
- F_{cr} = Critical value of deflection for column buckling, in.
- f = Natural frequency of spring, cps
- G = Modulus of rigidity, psi
- g = Gravitional acceleration, in. per sec per sec
- H = Free height of spring, in.
- K = Shear-stress factor
- K_F = Deflection factor
- m = End-fixity factor
- N = Number of active coils
- P = Applied axial load, lb
- P_{cr} = Critical column buckling load for spring, lb
- p = Tangent of helix angle
- S_c = Nominal shear stress at which torsional crippling occurs, psi
- S_{max} = Maximum combined shear stress, psi
- S_{nom} = Nominal shear stress, psi
- t = Tubing wall thickness, in.
- V_r = Initial release velocity of spring, in. per sec
- U = Unit energy-storage capacity of spring, in.-lb per lb
- γ = Specific weight of spring material, lb/in.^{3}

mH/D for compression springs having a circular cross section, either solid or hollow. The end-fixity factor m depends upon the type of end supports as shown by the listing in Fig. 3.

Although the type of end support in compression-spring applications is usually considered to correspond to Case 3 (Fig. 3), this arrangement is strictly applicable only when the ends are parallel. In practice, the nonparallel ends are free to rotate (or tilt) as in Cases 1 or 4. Even though at higher loads the ends touch the supports and become fixed, additional end moments have already been introduced. These moments reduce the actual buckling load to a value smaller than that calculated according to Case 3 (m = 1/2). Thus, for conservative design, actual compression-spring installations should be considered to have Case 1 supports.

Local Buckling: If a tubular spring has a wall thickness which is too small relative to the tube outside diameter, several kinds of local buckling or elastic instability may occur. The first kind is flexural crinkling (wrinkling) which may occur during the coiling process if adequate precautions are not taken. This wrinkling can be prevented by filling the spring with a low melting-point alloy be-

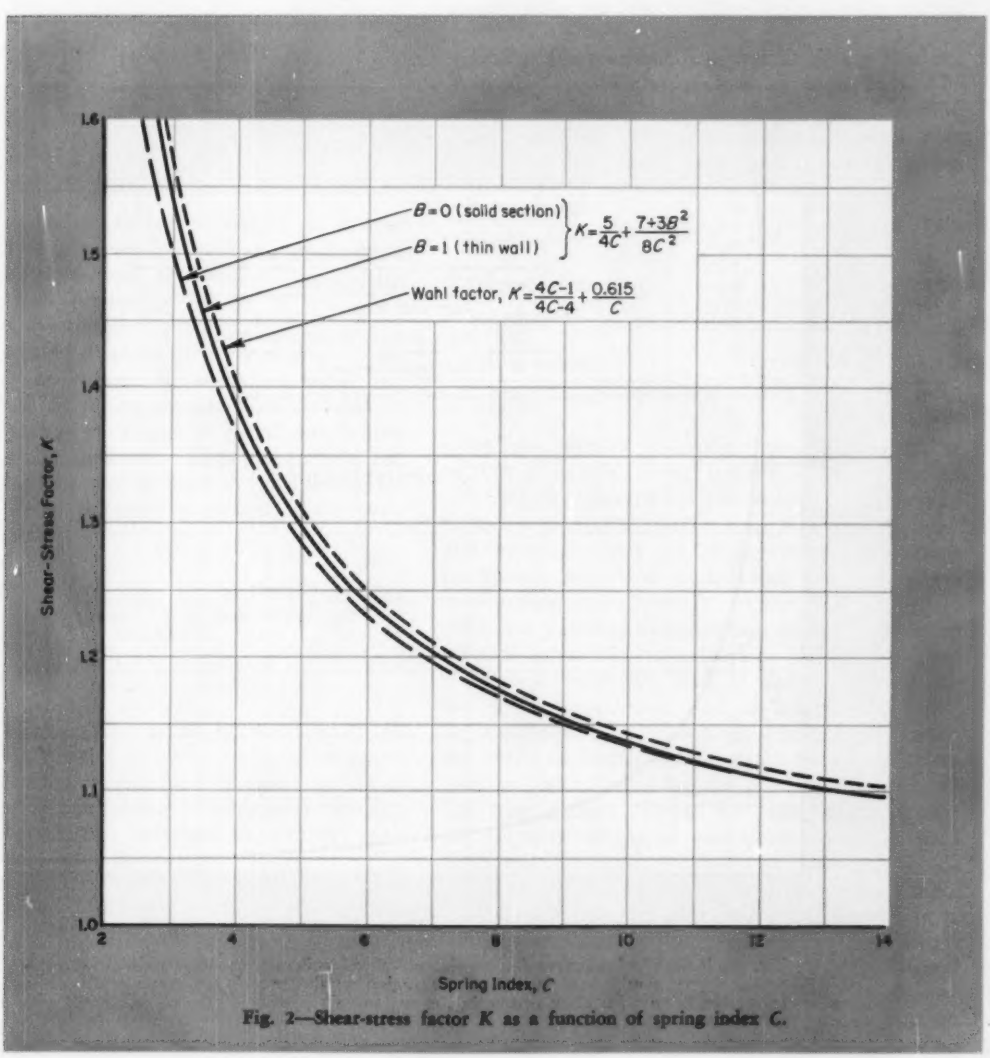


Fig. 2—Shear-stress factor K as a function of spring index C.

fore coiling. After the spring has been coiled, the alloy may be removed by heating.

Torsional shear crippling is a kind of local buckling or wrinkling which may occur during service use of the spring if the wall is too thin. However, to the best of the author's knowledge, no analysis of this problem has ever been made for a curved tube such as a tubular spring. Until such time as this study is carried out, the best available means for estimating when shear crippling will occur is to adapt the results of studies of torsional crippling of straight, thin-walled, circular tubes.[5]

Since the curvatures in two perpendicular directions at the inside of the coil (point *A* in Fig. 1) are opposite in sign and thus detrimental to elastic stability, critical stress in a thin-walled tubular spring is believed to be lower than that in a straight torque tube of the same cross-sectional dimensions. Therefore, it is suggested that shear-stress factor *K*, Fig. 2, be used as the reduction factor to account for the lower buckling stress of a curved tube as compared to a straight tube. Then, assuming Poisson's ratio to be 0.3, the nominal stress at which crippling occurs is estimated as

$$S_c = 0.715 \frac{E}{K} \left(\frac{t}{d} \right)^{3/2} \qquad (7)$$

The axial load corresponding to this stress level is calculated by solving Equation 1 for load *P*, where $S_{nom} = S_c$.

Use of internal pressure in a tubular spring has been suggested as a way to reduce wall thickness

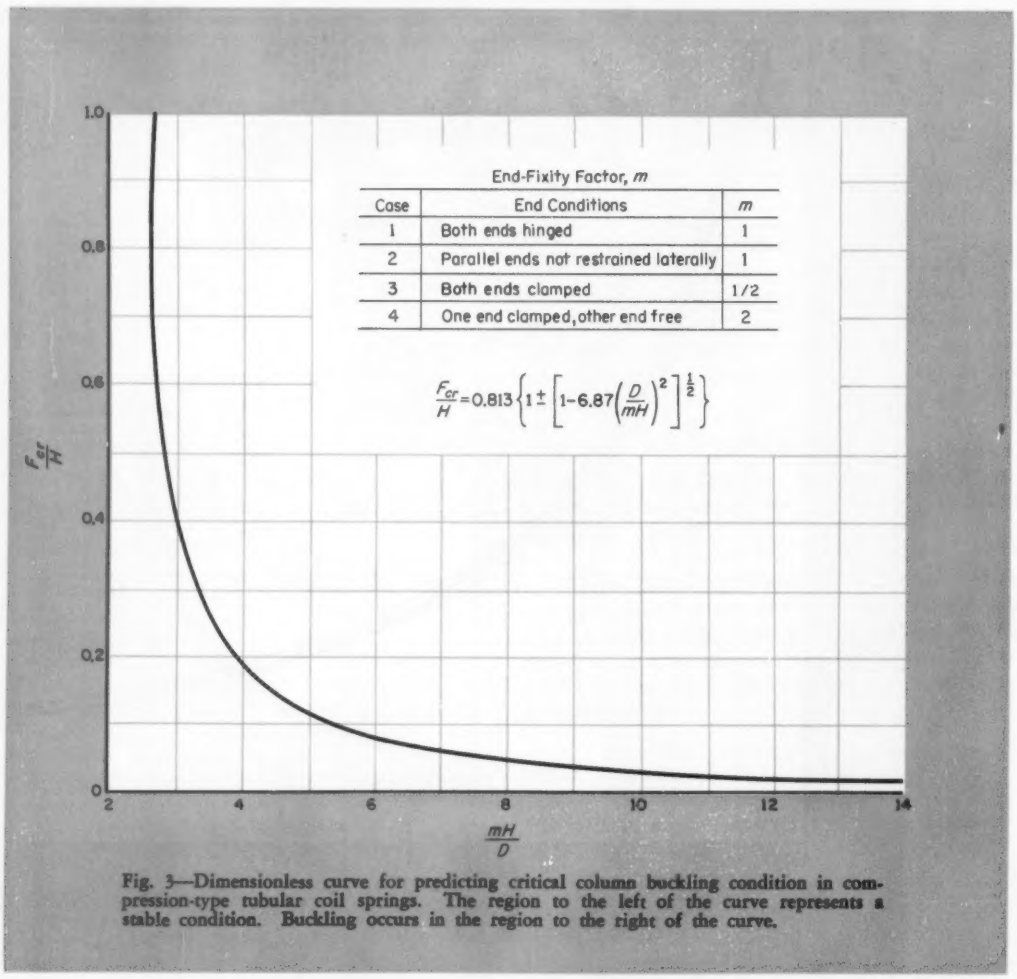


Fig. 3—Dimensionless curve for predicting critical column buckling condition in compression-type tubular coil springs. The region to the left of the curve represents a stable condition. Buckling occurs in the region to the right of the curve.

Table 1—Comparative Data for Replacement of Solid-Spring Nest with Single Tubular Spring

	Solid-Spring Nest		Single Tubular Spring*
	Individual Spring Data		
	Outer Spring	Inner Spring	
d(in.)	0.500	0.375	0.570
D(in.)	4.15	3.10	4.05
C	8.30	8.27	7.10
Total turns	13	14	11
H(in.)	15.75	13.06	14.12
KS_{nom}(psi)†	109,000	109,000	120,000
	Unit Performance Data		
P_{max}(lb)	1576		1700
Total weight (lb)	11.75		7.50

*B=0.509
†At Maximum load

with a corresponding saving in weight. It is true that the use of a pressuring medium results in a thinner permissible wall thickness. However, for the thinner-wall pressurized spring to carry the same load as the thicker-wall unpressurized spring, the tubing outside diameter must be increased. As it turns out, the increase in weight of metal due to the increase in tubing outside diameter exactly cancels the saving in weight of metal due to the decrease in wall thickness. Thus the pressurized spring is always heavier in total weight, because of the weight of the pressurizing medium itself, even if helium is used.

Energy-Storage Capacity: For a tubular spring, the energy-storage capacity per unit weight is

$$U = \frac{S_{nom}^2}{4\gamma G}(1 + B^2) \tag{8}$$

Release Velocity: The initial release velocity of a spring is the velocity at which it begins to move when it is suddenly released from some deflected position. The initial release velocity of a tubular spring compressed to a nominal shear-stress level S_{nom} is

$$V_r = S_{nom}\left[\frac{g}{2\gamma G}(1 + B^2)\right]^{1/2} \tag{9}$$

Since B is nearly equal to unity for very thin-walled springs and B is zero for solid-section springs, the maximum potential increase in release velocity for a tubular spring over a solid one is approximately 41 per cent. In applications where high release velocity is required, this increase is quite important.

Natural Frequency of Vibration: When a spring is repeatedly loaded at a frequency which is at or near its natural frequency, it undergoes resonance or surging. In applications such as valve springs or suspension springs, the natural frequency should be higher than the maximum operating frequency to prevent resonance. For a tubular spring, the natural frequency is

$$f = \frac{1}{2\pi C}\left[\frac{Gg}{2\gamma}(1 + B^2)\right]^{1/2} \tag{10}$$

This expression shows that it is potentially possible to increase the natural frequency 41 per cent by using a tubular spring of the same material and spring index as the original solid-section spring.

Design Comparison: The weight saving resulting from the use of tubular springs instead of solid springs is illustrated by the following equations, which were all obtained from the basic expression for unit energy-storage capacity of a tubular spring:

$$\frac{\text{Spring weight}}{\text{Maximum load}} = 2\left(\frac{\gamma G}{S_{nom}^2}\right)\frac{F_{max}}{1 + B^2} \tag{11}$$

$$\frac{\text{Spring weight}}{\text{Spring rate}} = 2\left(\frac{\gamma G}{S_{nom}^2}\right)\frac{F_{max}^2}{1 + B^2} \tag{12}$$

$$\frac{\text{Spring weight}}{\text{Energy-storage capacity}} = 4\left(\frac{\gamma G}{S_{nom}^2}\right)\frac{1}{1 + B^2} \tag{13}$$

Thus, the ratio of the weight of a tubular spring to that of a solid spring is $1/(1 + B^2)$, provided that certain quantities are the same for both springs: G and γ (spring material); F_{max}; S_{nom} (spring index and material); and one of the three performance parameters, maximum load, spring rate, or energy-storage capacity.

In many spring installations, design dimensions must be optimized to achieve a particular desired performance objective, such as maximization of initial load or maximum load, or the ratio of initial or maximum load to spring weight. Fortunately, the optimum spring indexes to achieve these objectives are not affected by the presence of a hole in the cross section. Thus, the same methods used for optimum design of solid springs can be used to optimize the design of tubular springs.

If a single solid spring in an existing installation, with fixed space and deflection requirements, is to be replaced with a tubular spring, the new installation will not carry as much load as the original installation unless a higher stress level is permissible. Although the tubular spring carries less actual load, it has a higher *ratio* of load to spring

weight. As a result, use of tubular springs should be considered in the initial design stage of a new product, so that proper space provisions can be made. If a tubular spring in which $B = 0.707$ is used, for example, it will carry 50 per cent more load than a solid spring of the same weight, deflection, spring index, and material. However, the tubular spring will require 41 per cent more diametral space and 41 per cent more axial space.

When a single tubular spring replaces a concentric nest of solid springs, these difficulties usually are not encountered. The reason is that a spring nest usually has a larger outside diameter than a single-spring installation; thus, there is more diametral space available for the tubular spring. An example of the replacement of a two-spring nest with a single tubular spring is given in Table 1. These data represent actual spring designs that were made up for comparison tests.

The single tubular spring occupied the same space envelope and was subjected to the same operating deflection as the original two-spring nest. As indicated in the tabulation, use of the tubular spring resulted in a 36 per cent reduction in weight. At the same time the maximum load capacity was increased 8 per cent. This increase in load capacity is due mainly to the use of a stronger material which permitted a 10 per cent increase in maximum stress level.

The tubular spring and the original nested-spring set were installed in identical housings and simultaneously subjected to identical cyclic deflections in a test rig to simulate actual service. After 100,000 cycles, neither the tubular spring nor the original nested springs showed any signs of fatigue cracking.

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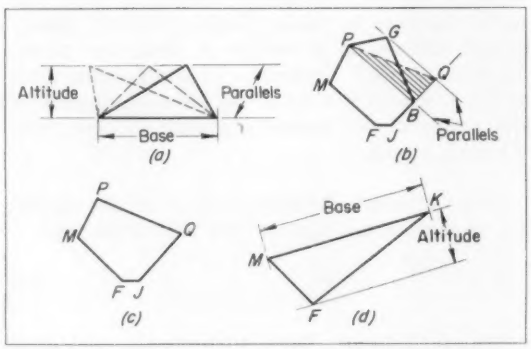
4. J. A. Haringx—"On Highly Compressible Springs and Rubber Rods, and Their Application for Vibration-Free Mountings," *Philips Research Reports*, Vol. 3, 1948, pp. 401-499.
5. S. Timoshenko—*Theory of Elastic Stability*, McGraw-Hill Book Co., New York, 1936, pp. 480-490.

Tips and Techniques

Finding Polygon Areas

The area of a polygon can be easily found by reducing it to a triangle of equal area. The method can be used with a polygon of any number of sides and is based on the fact that the area of a triangle is half of the base times the altitude, *a*. For the polygon shown, first extend *JB* to reach point *Q*, sketch *b*. *PQB* replaces *PGB*, and the polygon has lost one side, *c*. Continue the process until the polygon is reduced to a triangle *KMF*, sketch *d*, equal in area to original polygon.—FRANCIS J. BURNS, *professor, Newark College of Engineering, Newark, N. J.*

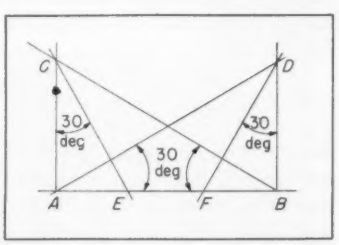


Trisecting A Line

A geometric method of dividing a line into three equal parts is given by the following procedure:

1. Erect perpendiculars at ends *A*, *B*.
2. Draw lines through *A* and *B* at 30 deg to base to find *C* and *D*.
3. Draw lines through *C* and *D* 30 deg to sides, intersecting base at *E* and *F*.
4. $AE = EF = FB$

—FLOYD M. CLEVELAND, *Inkster, Mich.*



Recommended metal combinations to avoid . . .

Galvanic Corrosion

EUGENE D. VEILLEUX
Mechanical Engineer
Sanders Associates Inc.
Nashua, N. H.

GALVANIC corrosion results when two dissimilar metals come into contact with an electrolyte. Rate of corrosion depends upon the potential difference between the metals and the type of electrolyte. Galvanic corrosion can be minimized, if not eliminated, by combining two dissimilar metals of the least potential difference.

Metals can be chosen for minimum potential difference by using a galvanic-series chart, Fig. 1. The chart grades metals from least corrosive (cathodic) to most corrosive (anodic). All metals in one group are comparatively free from corrosion when combined with another member of the same group. The line of least galvanic attack is formed by the intersection of identical metals, whose combination results in least potential difference. The hatched area is a region of permissible corrosive action. Any combination of metals whose intersection lies outside of the hatched area represents a combination high in corrosive activity, which requires protective coating.

As the worst example, magnesium or its alloys are highly anodic, and should not be used with other materials without protective coating for one or both metals.

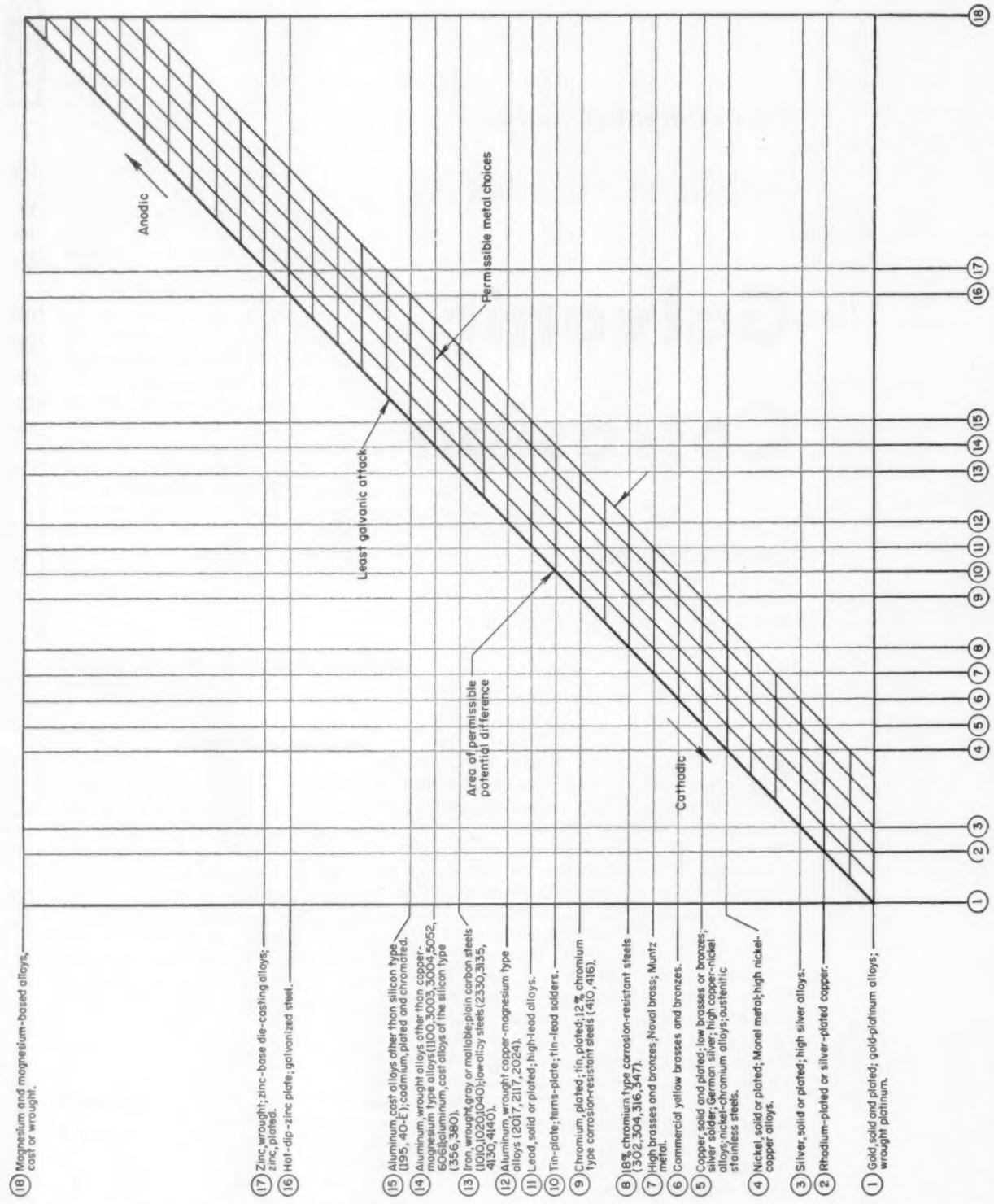
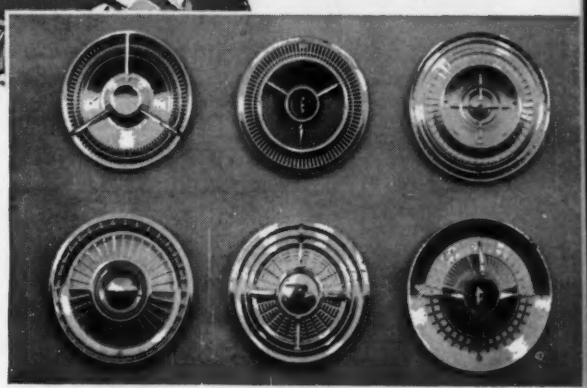

Anodic
Least galvanic attack
Permissible metal choices
Area of permissible potential difference
Cathodic
(18) Magnesium and magnesium-based alloys, cast or wrought.
(17) Zinc, wrought; zinc-base die-casting alloys; zinc, plated.
(16) Hot-dip-zinc plate; galvanized steel.
(15) Aluminum, cast alloys other than silicon type (195, 40-E); cadmium, plated and chromated.
(14) Aluminum, wrought alloys other than copper-magnesium type alloys (1100, 3003, 3004, 5052, 6061); aluminum, cast alloys of the silicon type (356, 380).
(13) Iron, wrought, gray or malleable; plain carbon steels (1010, 1020, 1040); low-alloy steels (2330, 3135, 4130, 4140).
(12) Aluminum, wrought copper-magnesium type alloys (2017, 2117, 2024).
(11) Lead, solid or plated; high-lead alloys.
(10) Tin-plate; terne-plate; tin-lead solders.
(9) Chromium, plated; tin, plated; 12% chromium type corrosion-resistant steels (410, 416).
(8) 18% chromium type corrosion-resistant steels (302, 304, 316, 347).
(7) High brasses and bronzes; Naval brass; Muntz metal.
(6) Commercial yellow brasses and bronzes.
(5) Copper, solid and plated; low brasses or bronzes; silver solder; German silver; high copper-nickel alloys; nickel-chromium alloys; austenitic stainless steels.
(4) Nickel, solid or plated; Monel metal; high nickel-copper alloys.
(3) Silver, solid or plated; high silver alloys.
(2) Rhodium-plated or silver-plated copper.
(1) Gold, solid and plated; gold-platinum alloys; wrought platinum.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18

Fig. 1—Galvanic series of dissimilar metals.

Circle 490 on Page 19→



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High-Temperature Bearing Materials

O. W. McMULLAN
Director of Research and Development
Bower Roller Bearings Div.
Federal-Mogul-Bower Bearings Inc.
Detroit, Michigan

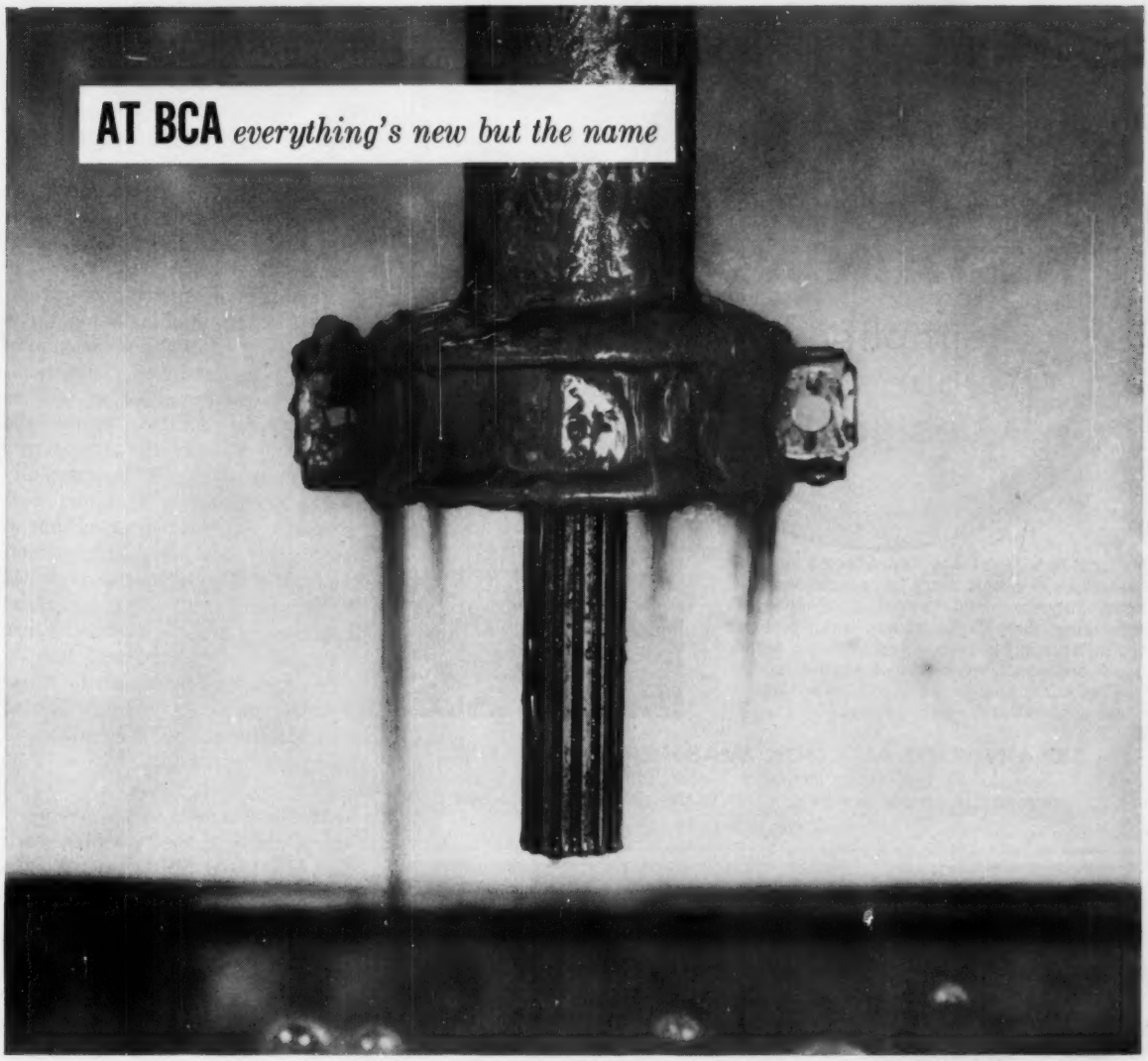
PACED by the requirements of gas-turbine engines, a growing number of products require materials for high-speed parts operating at high temperatures. Parts moving at high speeds necessarily require high strength. For antifriction bearings, other requirements are: Hardness, wear and gall resistance, and dimensional stability beyond the capacities of the more commonly used metals, both ferrous and nonferrous.

Since steel is the major constituent in most antifriction bearings, this paper will deal mostly with steel and its heat treatment. For this discussion, materials for antifriction bearings are classified according to loosely defined temperature limits: Up to 450 F, 600 F, 1000 F, 1500 F, and above 1500 F.

Conventional Steels: For the group up to 450 F, conventional bearing steels, such as SAE 52100 and 4620, can be used. At higher

Table 1—Composition of High Temperature Steels

Steel	C	Mn	Si	Cr	Mo	Other
a. Up to 600 F:						
MHT	0.95-1.10	0.25-0.45	0.25-0.55	1.30-1.60	....	Al: 0.75-1.25
TBS-600	0.95-1.10	0.60-0.80	0.85-1.20	1.25-1.65	0.25-0.35	....
CBS-600	0.17-0.22	0.50-0.70	0.90-1.25	1.25-1.65	0.90-1.10	....
C	0.17	0.55	0.30	....	2.98	....
b. Up to 1000 F:						
T-1	0.65-0.75	0.20-0.40	0.20-0.40	3.75-4.50	....	W: 17.25-18.75 V: 0.90-1.30
M-1	0.75-0.85	0.20-0.40	0.20-0.40	3.75-4.50	7.75-9.25	W: 1.15-1.85 V: 0.90-1.30
M-2	0.78-0.88	0.20-0.40	0.20-0.40	3.75-4.50	4.50-5.50	W: 5.50-6.75 V: 1.60-2.20
M-10	0.85	0.25	0.25	4.00	8.00	V: 2.00
M-50	0.80	0.30	0.30	4.00	4.25	V: 1.00
Halmo	0.58	0.30	1.00	5.00	5.25	V: 0.65
VSM	0.70	0.50	1.10	3.00	5.25	....
315	0.10-0.15	0.40-0.60	0.20-0.35	1.35-1.75	4.80-5.20	Ni: 2.60-3.00
c. 800 to 1000 F:						
51440C	0.95-1.20	1.00 max	1.00 max	16.00-18.00	0.75 max	
Modified	0.95-1.20	1.00 max	1.00 max	14	4	



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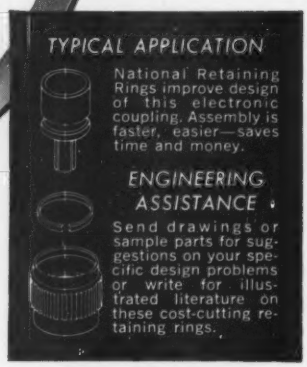
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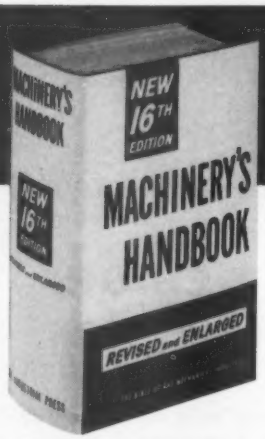

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temperatures, their hardness drops, and they do not have the required wear resistance and endurance. Since strength varies directly with hardness, and since hardness and volume changes occur simultaneously, hardness tests can be used as a measure of endurance and dimensional stability.

Bearing components must be tempered, before final grinding, at a temperature above the maximum expected in operation. Since tempering is time-sensitive as well as temperature-sensitive, either the tempering time or the temperature must make the parts dimensionally stable at maximum operating temperature. Normal tempering time at about 50 F above the maximum temperature during operation has proved to be satisfactory. This, of course, lowers the hardness and endurance limits of the conventional bearing steels and puts somewhat more restrictive limits on their application than indicated by the maximum operating temperature.

Middle-Range Steels: For temperatures above those for which steels SAE 4620 and 52100 are suitable, two courses are open for bearing producers. One is to select existing compositions that have been used for other purposes at elevated temperatures. The other is to develop new compositions. Both courses are followed. There has been a general tendency in the bearing industry to select compositions that keep to a minimum the more highly strategic, scarce, and more costly alloying elements. For this reason cobalt and tungsten were not included in some studies of bearing alloys.

In a Bowers search for high-temperature steels, preliminary tests indicated the need for more basic knowledge about the effect of individual alloying elements. At 550 F and at 700 F, nickel promotes softening, and on a hardness basis is not a suitable alloying element. Aluminum, molybdenum, and silicon promoted retention of hardness. Compositions of steels that will maintain a hardness of Rockwell 60C after tempering at 600 F appear in Table 1*a*.

High-Temperature Steels: Steels in the third group are suitable for

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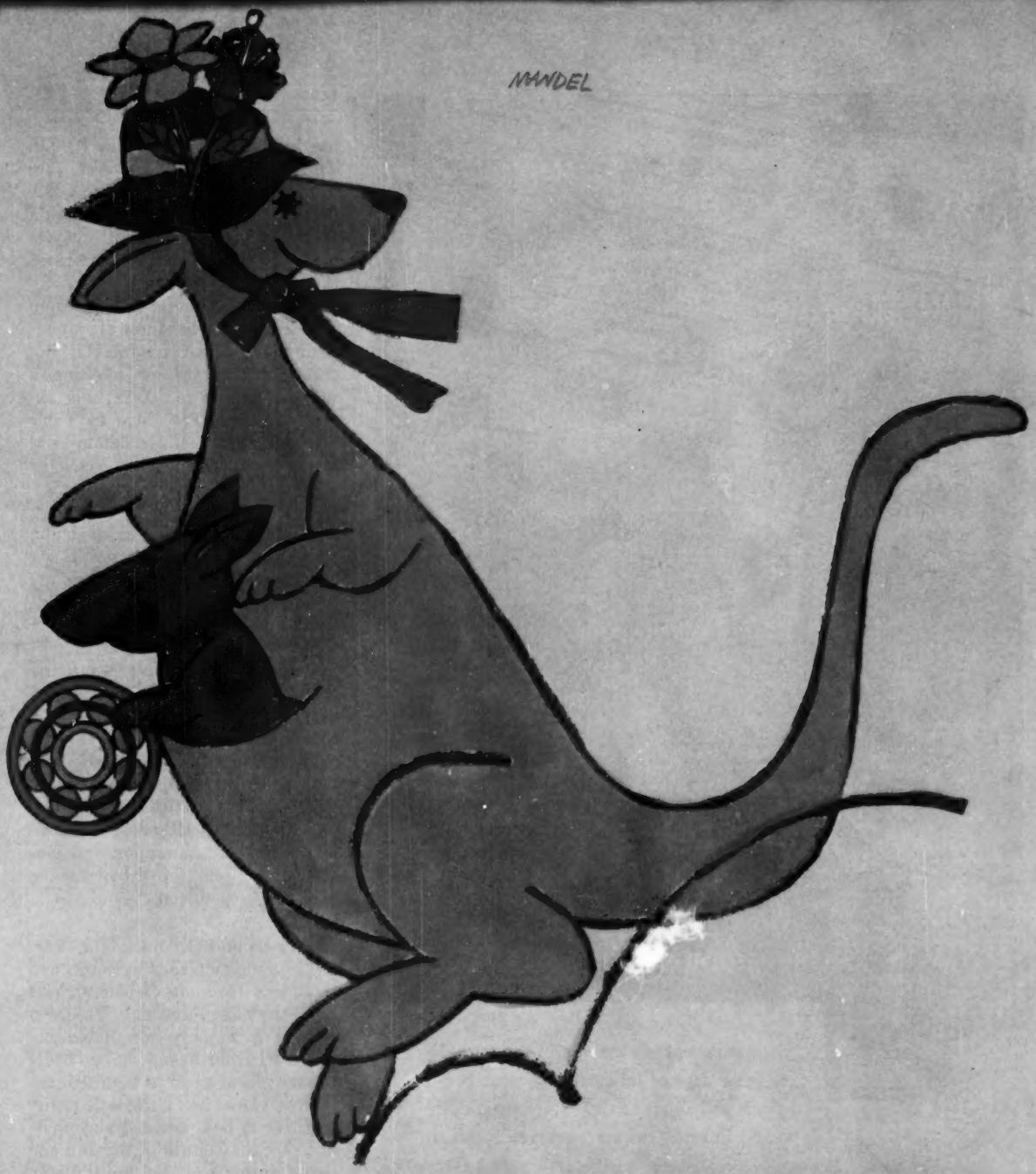
Circle 494 on Page 19→



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use in the range of 600 to 1000 F. Their applications, however, are usually in the range of 400 to 600 F because of a lack of suitable liquid lubricants above 600 F. The analyses of a number of such steels are listed in Table 1*b*.

Suitability of steels in this group is based on the hardness after tempering. However, hardness is not the only criterion for selecting a steel for use up to 1000 F. For example, all of those listed in Table 1*b* are subject to oxidation and scale formation unless protected by a lubricant or inert atmosphere.

Stainless Steels: When oxidation may occur or corrosive media are encountered, stainless properties are necessary. SAE 51440 C or modifications are used. These steels are subject to some oxidation as temperatures increase, but have been found useful at 800 to 1000 F. Chemical compositions of 51440 C and a modification are given in Table 1*c*.

Ferrous-base alloys become unsatisfactory at temperatures above 1000 F. The so-called "superalloys" are nonferrous, with base compositions of cobalt, chromium and molybdenum. Some have had use up to 1500 F or higher.

Cermets and Ceramics: The "hottest" group includes cermets and ceramics. Titanium carbide appears to be the most successful. Tungsten carbide is entirely unsuitable because it oxidizes and flakes badly when exposed to air at high temperatures. Chromium carbide is rather sensitive to both thermal and physical shocks. Control of the size and shape during sintering are difficult, and diamond grinding is slow and expensive. Ceramics for bearings are in the experimental stage.

Heat Treatment: It is desirable to use a case-hardened steel for high temperatures. Some objectives are to develop a steel that would:

1. Contain only the more readily available alloying elements.
2. Carburize readily to a sufficiently high percentage of carbon.
3. Have a composition that could be carburized and hardened in production type furnaces rather than special equipment such as tool hardening furnaces for speed steel.

Thermal treatments are normally used to decompose excessive austenite. Single tempering, however, regardless of time or temperature, may be unsatisfactory. Multiple tempering in short periods of not more than one or two hours each can produce a transformation product (martensite) with the required degree of hardness.

The optimum temperature for multiple tempering depends on the per cent and kind of alloying elements. For steel No. 315, temperatures up to 800 F are too low to cause little if any transformation, whereas 1100 F is so high as to cause undesirable softening of the reaction product. The best temperature was found to be 1000 F for this steel.

SAE Paper No. 122A presented at the SAE Annual Meeting, Detroit, Mich., January, 1960, 9 pp.

management

Administration of Research And Development Projects

Howard L. Mills, Specialist, Engineering Programs, Flight Propulsion Div., General Electric Co., Evendale, Ohio

Long-accepted management methods adapted to research and development's needs for flexibility. Control of any function, regardless of its nature, depends upon an unbroken cycle of processes. In this discussion they are called planning, operation, measurement, and analysis. Each of these elements must feed directly into the next, with the results of "analysis" going back as an essential ingredient for the next round of "planning." While this "management cycle" remains intact, there can be effective controls.

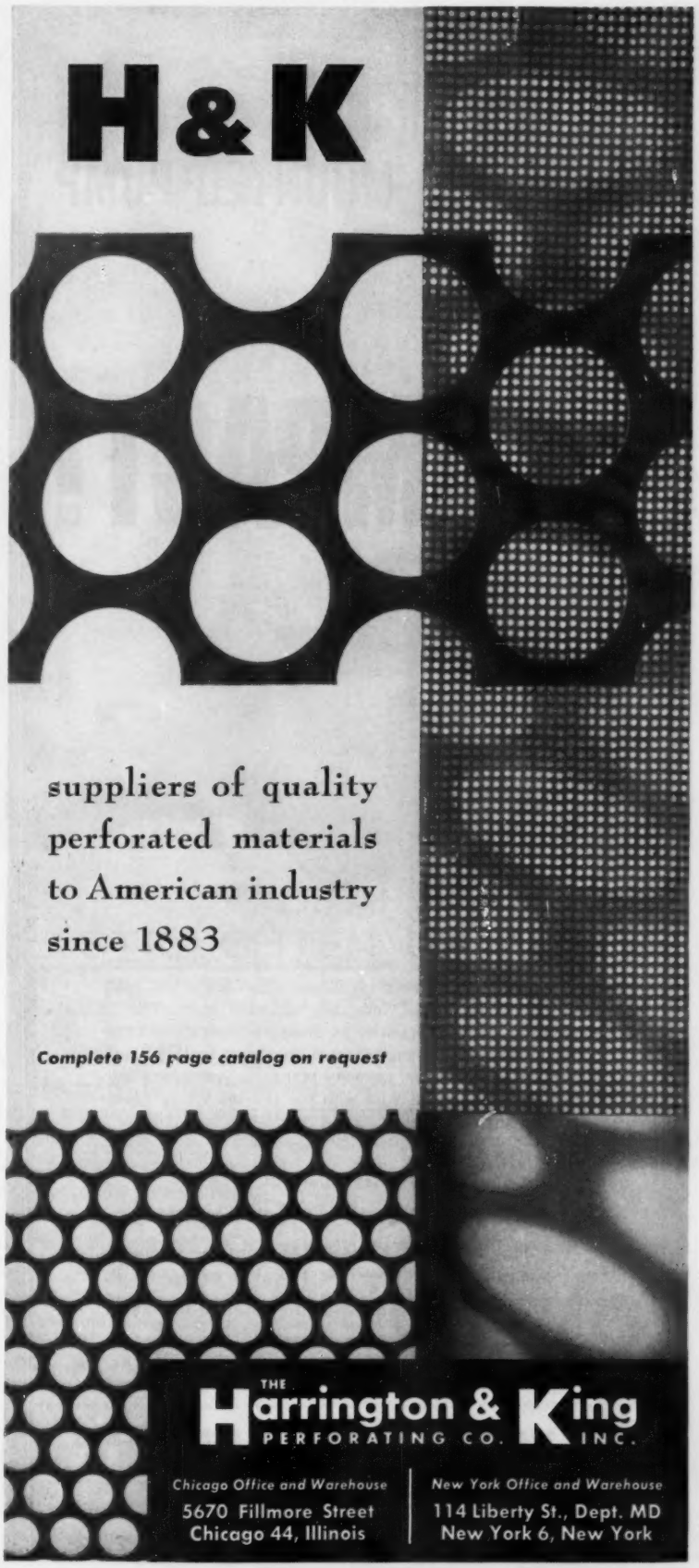
ASME paper No. 59-A-246 presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 5 pp.

techniques

Reliability Design Criteria

J. M. Brown, H. L. Leve, and P. H. White, Design Integration Dept., Hughes Aircraft Co.

Practical procedures for obtaining more use of environmental and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strength estimates for design purposes. In design, there are essentially three types of test procedures giving estimated parameters, three idealizations of these test types in which the estimated parameters are regarded as true parameters, and a single discrete value idealization of test results, a total of seven strength and seven environment types. Hence, there are forty-nine different design procedures. An example is given of the design procedure for an environment which is a single discrete value and a strength distribution which is estimated from results of tests for variables.

SAE Paper No. 101V, *presented at the SAE National Aeronautic Meeting, Los Angeles, October,* 1959, 17 *pp.*

materials

Spark-Hardening of Metals

N. C. Welsh, Research Laboratory of Associated Electrical Industries Limited, Aldermaston, Berkshire, England

Influence of electric sparks on the structure and hardness of metal surfaces. A vibrating electrode is used to generate the sparks. Each spark fuses a small volume of metal, which rapidly chills when the discharge ceases. Steel surfaces are hardened by the thermal cycling, but evidence is given that elements derived from the sparking medium accentuate the hardness change. Thus, nitrogen from the atmosphere or carbon from an oil promote hardening even in pure iron. The same elements confer great hardness on metals such as titanium and zirconium, which react chemically to form hard compounds. Surface alloying also occurs by the transfer of matter between the sparking contacts. Experiments with sintered-carbide electrodes show that very hard, wear-resistant layers can be formed on most engineering metals.

Paper No. 1951, *Journal of the Institute of Metals, Vol.* 88, 1959-60, *pp.* 103 to 111.

Seal Materials for High Temperature Applications

R. H. Baskey

Rotating seal materials developed by powder metallurgy techniques

for applications at high speeds and high temperatures. A systematic wear study, without lubrication, included several commercially available materials and the following types of experimental materials: 1. Pure refractory hard metals. 2. Binary alloys of refractory hard metals bonded with nickel. 3. Ternary alloys of refractory hard metals bonded with nickel and infiltrated with silver. Two ternary alloys, containing nickel-bonded WB or CrN and infiltrated with silver, showed superior wear qualities against either tool steel or a nickel-chromium-iron alloy at a sliding speed of 29,000 fpm under a 14 psi load and at ambient temperatures as high as 1300 F. A commercial titanium carbide composition showed excellent wear characteristics in contact with an identical composition at a sliding speed of 14,000 fpm under a 16 psi load and at an ambient temperature of 1050 F.

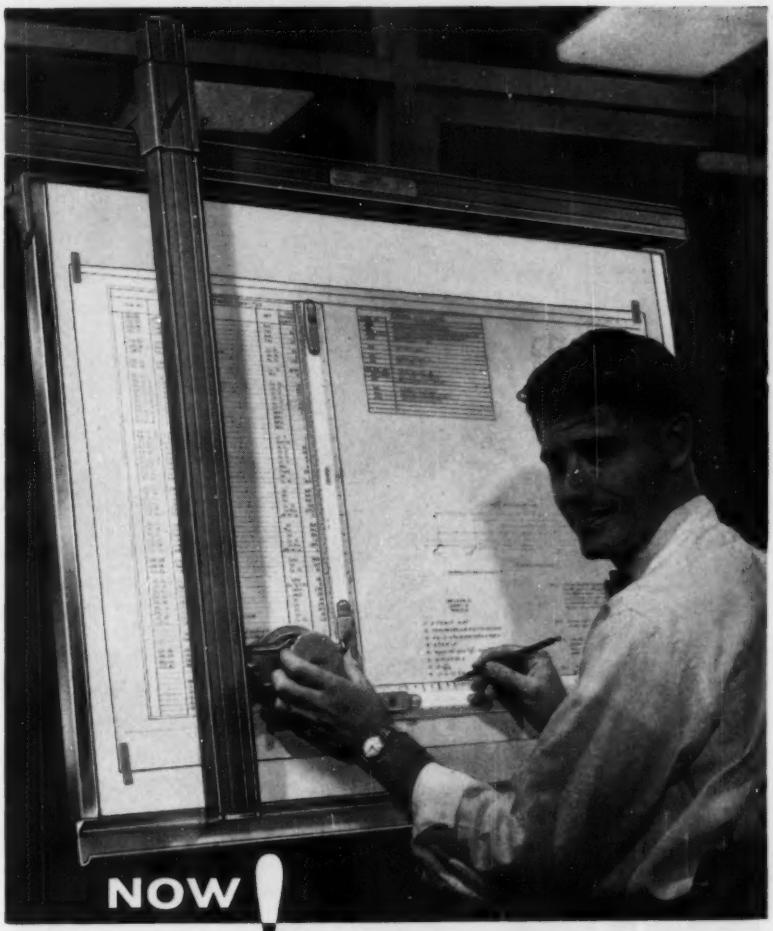
ASLE paper No. 59LC-8 presented at the ASLE/ASME Lubrication Conference, New York, N. Y., October, 1959, 30 pp.

Sliding Characteristics of Metals at High Temperatures

M. B. Peterson, J. J. Florek, and R. E. Lee

Friction and wear characteristics of a number of metals sliding against themselves. With iron, copper, nickel, molybdenum, and chromium, high friction and considerable surface damage resulted until a particular transition temperature was reached. Above this temperature, a considerable improvement in the sliding characteristics was observed. The transition temperatures for the various metals were: Iron, 100-200 F; copper, 400-500 F; nickel, 1200-1400 F; molybdenum, 800-900 F; and chromium, 800-1100 F. This improvement was associated with the generation of oxide in the sliding track. When tested as lubricants, a number of the metal oxides were effective in reducing friction and preventing surface damage. Since the softer oxides were the more effective it was hypothesized that metals which form these oxides would have the best sliding characteristics at high temperatures.

ASLE paper No. 59LC-5 presented at



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the ASLE/ASME Lubrication Conference, New York, N. Y., October, 1959, 14 pp.

mechanical

Shear Buckling of Bars

G. Hermann, Associate Professor of Civil Engineering, Columbia University, New York, N. Y., and A. E. Armenakas, Associate Professor of Civil Engineering, Cooper Union, New York, N. Y.

A perfectly straight bar, subjected to a state of uniform shear stress, will buckle, in a manner similar to a column under compression, if the shear stress exceeds a certain critical value. The buckling equations are obtained by the Newtonian approach, and also by the application of the principle of minimum potential energy. In order to provide additional insight into this buckling mechanism, a simple model is introduced and analyzed.

ASME paper No. 59-A-152 presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 3 pp.

Strength of Gear Teeth By Cantilever-Plate Theory

E. J. Wellauer, Director, and A. Seireg, Advisory Engineer, Research and Development, The Falk Corp., Milwaukee.

A semiempirical solution for a cantilever plate under transverse loads at any location on its surface. The solution, which is based on the principle of superposition, and a proposed moment-image method shows good agreement with results from strain-gage investigations on cantilever plates simulating the gear tooth. The effects of the position of the line load and the variation of load intensity on the stress distribution at the root are discussed.

ASME Paper No. 59-A-50, presented at the Annual Meeting, Atlantic City, N. J., November, 1959, 8 pp.

Refining Finite-Difference Calculations in Kinematics

Bernard W. Shaffer, Professor of Mechanical Engineering, New York University, New York, and Irvin Krause, Dept. of Drafting, City College of New York.

First and second finite-difference expressions are derived for the first three derivatives of displacement

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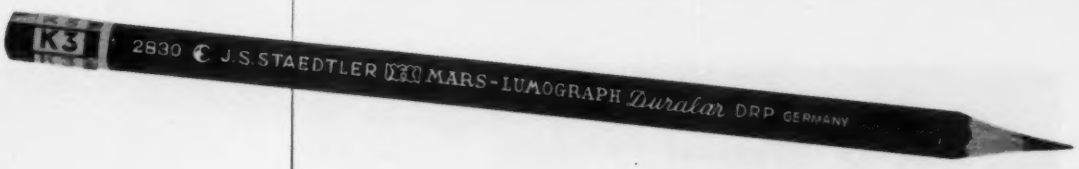
Circle 500 on Page 19→



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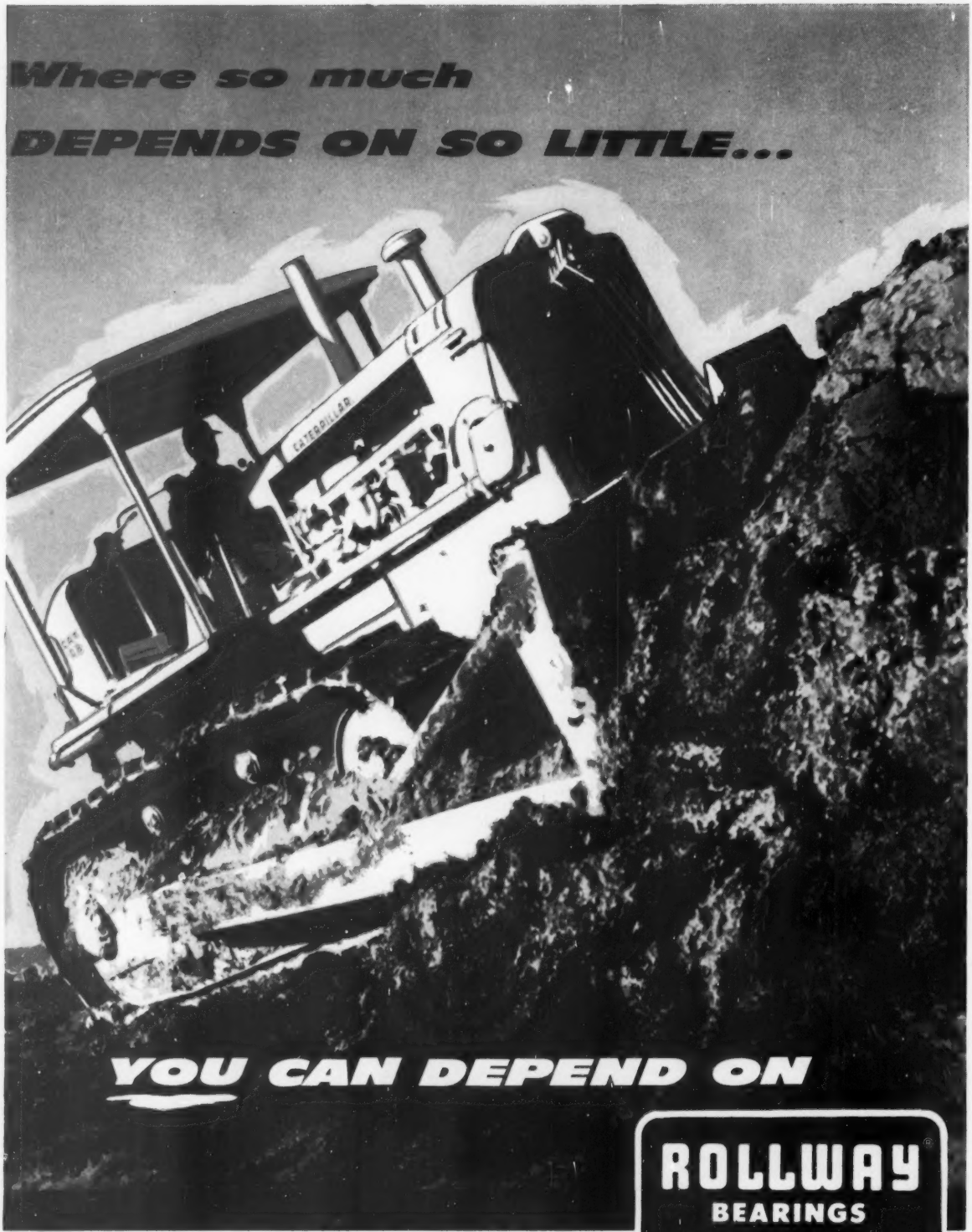

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with respect to time. The numerical results obtained by applying these difference expressions to a specific cam-follower mechanism are found to be in good agreement with the values obtained by successive differentiation of the displacement-time equation. Procedures are provided for evaluating and improving the numerical results.

ASME Paper No. 59-A-53, presented at the Annual Meeting, Atlantic City, N. J., November, 1959, 4 pp.

Performance of Hydrostatic Thrust Bearings

R. C. Elwell and B. Sternlicht, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

Two types of circular hydrostatic thrust bearings using incompressible lubricants. Design equations for load-carrying capacity, stiffness, and flow, are obtained for three different types of flow restriction—orifice, capillary, and constant flow. The equations are verified by experiment. Each method of restriction imparts its own characteristics on the bearing performance. Constant flow, for instance, results in the stiffest bearing under certain conditions, and capillary restriction is unaffected by temperature changes.

ASME paper No. 59-A-152 presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 7 pp.

Combined Operation of Diesel Engines and Gas Turbines

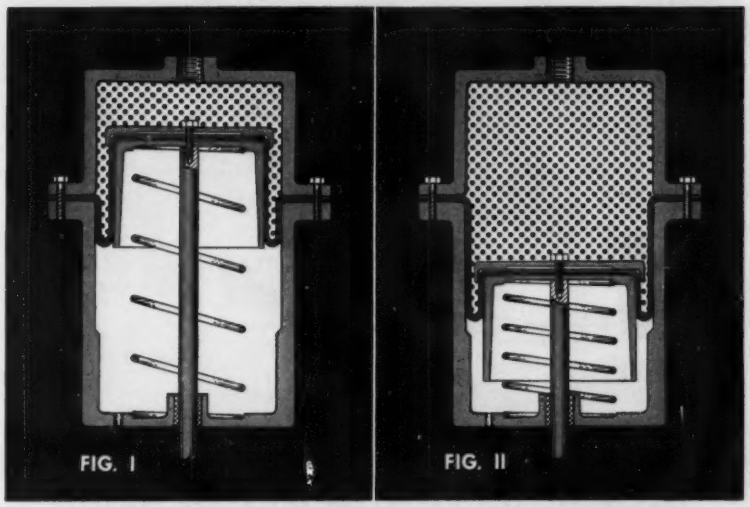
Ernest Chatterton, Design Consultant

Potential performances attainable from three arrangements for both two-cycle and four-cycle engines with and without charge cooling. The arrangements are: Turbocharging, compounding, and the gas generator. Conclusions are:

1. Use of high air manifold pressures in a combination of a diesel engine and a gas turbine permits the use of greatly increased specific power outputs without the necessity for exceeding established practical limitations.

2. The two-cycle engine gives a better response to a turbine than the four-cycle engine, particularly at higher manifold pressures.

3. The simple "turbocharged"



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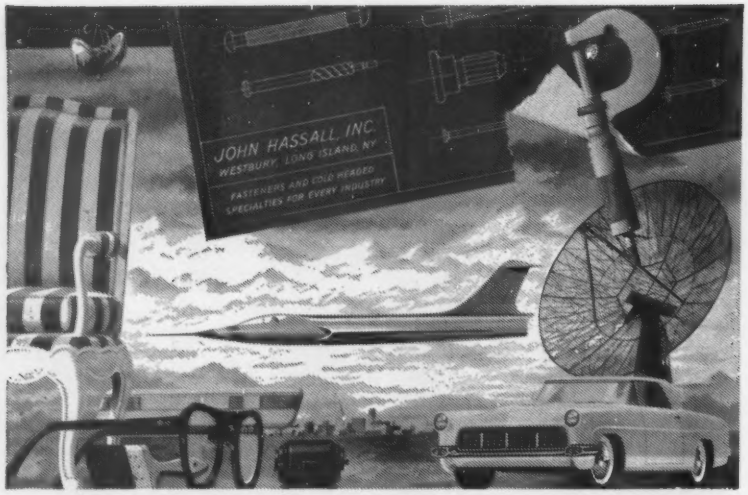

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engine is not suitable for exploitation of the higher degrees of supercharge owing to the restricted operating speed range obtainable.

4. The "compound" engine offers high maximum powers at high manifold pressures, coupled with good thermal efficiencies and a wide speed range, but it suffers from the disadvantage that its power falls off rapidly with reduction in crankshaft speed unless complexities are introduced in the gearing arrangements between the engine and the compressor.

5. The "gas generator" at high manifold pressures produces results comparable with the compound engine and, owing to its free power turbine, can maintain very high torques at low output shaft speeds.

"The Diesel Engine in Association with the Gas Turbine," *Presented at an Ordinary Meeting of the Institution of Mechanical Engineers, London, January,* 1960, 18 *pp.*

Factors for Rating Strength of Helical Gears

E. J. Wellauer, Director, Research and Development, The Falk Corp., Milwaukee, Wis.

Factors used to rate the strength of helical-gear teeth by means of the fundamental tooth-strength formula developed by the American Gear Manufacturers Association's Gear Rating Committee. The new approach combines different concepts of geometry factors, an improved evaluation of dynamic loads, rational allowable stresses, and risk or reliability considered as a statistical probability. In addition, the inclusion of the effect of operating error and load-distributing tooth flexibility provides an accurate means for helical-gear strength rating.

ASME Paper 59-A-21 *presented at the Annual Meeting, Atlantic City, N. J., November-December,* 1959, 8 *pp.*

Root Lubrication Effects on Cantilever Beam Damping

R. V. Klint and R. S. Owens, Research Laboratory, General Electric Co., Schenectady, N. Y.

Lubricating the root contact surfaces of a simple cantilever beam will increase the vibration damping

Circle 504 on Page 19→

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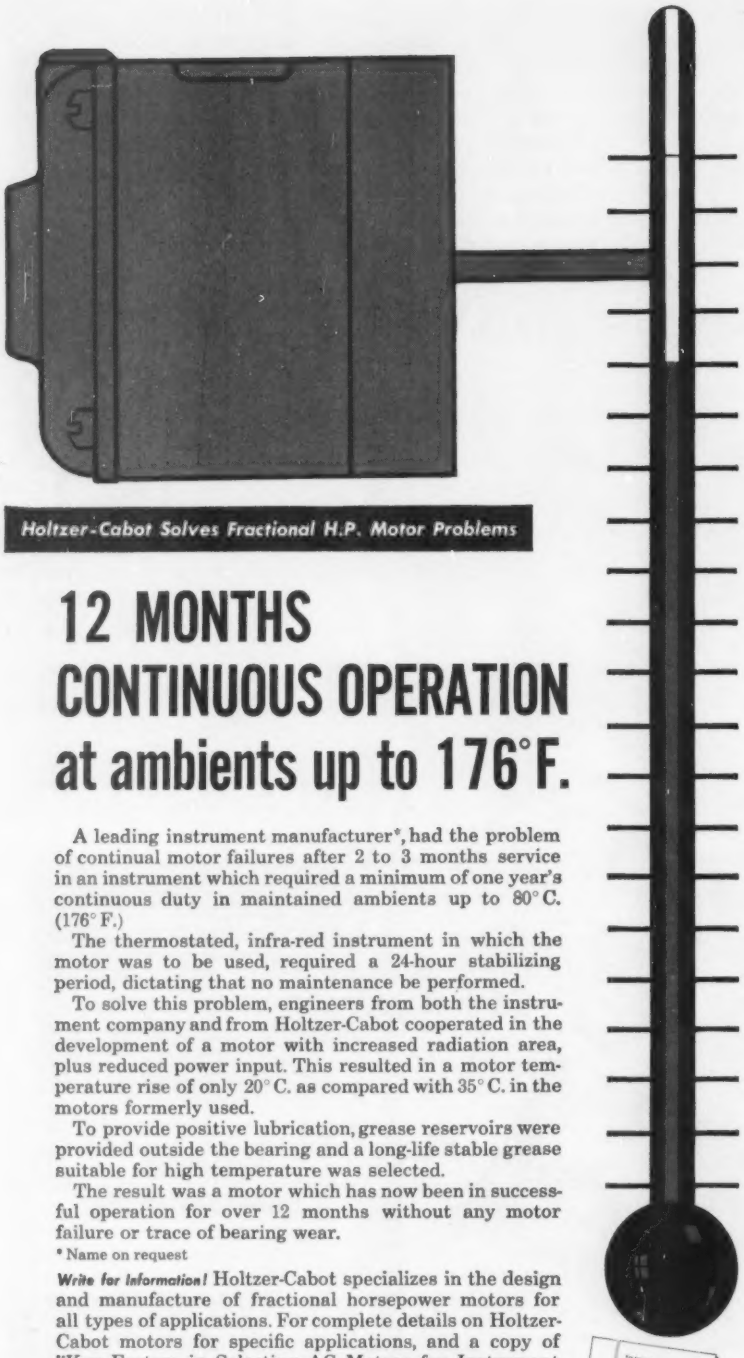

Holtzer-Cabot Solves Fractional H.P. Motor Problems

12 MONTHS CONTINUOUS OPERATION at ambients up to 176°F.

A leading instrument manufacturer*, had the problem of continual motor failures after 2 to 3 months service in an instrument which required a minimum of one year's continuous duty in maintained ambients up to 80° C. (176° F.)

The thermostated, infra-red instrument in which the motor was to be used, required a 24-hour stabilizing period, dictating that no maintenance be performed.

To solve this problem, engineers from both the instrument company and from Holtzer-Cabot cooperated in the development of a motor with increased radiation area, plus reduced power input. This resulted in a motor temperature rise of only 20° C. as compared with 35° C. in the motors formerly used.

To provide positive lubrication, grease reservoirs were provided outside the bearing and a long-life stable grease suitable for high temperature was selected.

The result was a motor which has now been in successful operation for over 12 months without any motor failure or trace of bearing wear.

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National Pneumatic Co., Inc., Boston 19, Mass.

of the beam. Evidence is available for cantilever beams made of cold-rolled steel, stainless steel, and brass, with contact surfaces dry and greased. Soft-metal platings, as alternate lubricants, produce a significant increase in the damping of cantilever beams. While this increase is not so great as for greased surfaces, the use of platings appears promising.

ASLE Paper No. 59LC-9 presented at the ASLE/ASME Lubrication Conference, New York, N. Y., October, 1959, 18 pp.

Hydrostatic Gas Bearings

John H. Laub, Research Group Supervisor, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.

Characteristics and capabilities of orifice-regulated hydrostatic gas bearings which make them suitable for instrument applications. In particular, gimbal bearings for inertial guidance systems can be designed with negligible starting torque and high stiffness, and for operation at extreme temperatures. Based on Euler's equation, expressions for the significant parameters, i.e., pressure profile, gas-flow rate, gap height, and load-carrying capacity of pad and step bearings, are developed. These parameters yield results which are in excellent agreement with experimental data. The test fixture incorporates pneumatic loading by means of a bellows-suspended piston which is prevented from cocking by an air bearing.

ASME Paper No. 59-Lub-1 presented at the ASME/ASLE Lubrication Conference, New York, N. Y., October, 1959, 10 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London S.W. 1, England.

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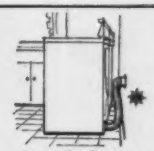

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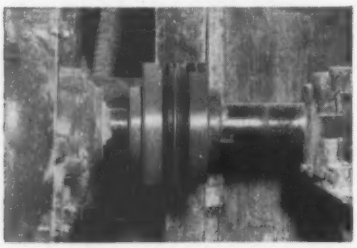

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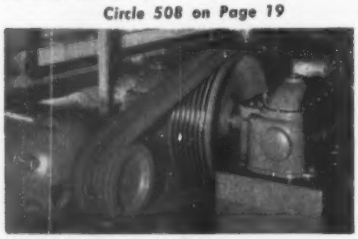

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Helpful Literature for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Miniature Connectors

Center screwlock miniature rectangular power connectors are subject of Folder 1900. Outline and mounting dimensions for 34, 78, 104, and 130-contact plugs and sockets are presented. Units have closed entry contacts. 6 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle 671 on Page 19

Pneumatic Timer

For use in explosive hazard areas or remote field locations where electrical power is not available, Model 20 Servo-Gauge Oscillator is described in Bulletin P-20. Adjustable from 0.3 to 60 cycles per min, the unit sends out a repetitive signal impulse of a preset magnitude, or of a variable magnitude if initiated by an external controller. 2 pages. Associated Control Equipment Inc., Box 136, Coraopolis, Pa.

Circle 672 on Page 19

Regulating Relief Valves

For water or oil pressure regulation up to 500 psi, the No. 280 Type G valve will relieve at adjustable pressures in four available ranges. Bulletin includes construction features, application information, and flow table. 2 pages. Atlas Valve Co., 280 South St., Newark 5, N. J.

Circle 673 on Page 19

Molding Materials

A guide in the selection of GE plastic molding materials is available as an aid to designers, molders, fabricators, formulators, and users. Booklet CDC-370 includes tabular data on polycarbonate resins, phenolic resins, varnishes, molding powders, and fused magnesium oxide. 12 pages. General Electric Co., Chemical Materials Dept., Pittsfield, Mass.

Circle 674 on Page 19

Electric Tachometers

Six types of generators and nine styles of indicators provide versatility of application of accurate speed-indication systems. Brochure describes remote, multiple, and monitor indication. 4 pages. Madison Electric Products Inc., Madison, Ohio.

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Precision Instrument Components

New, pocket-size catalog offers technical details, MIL specifications, and complete drawings of over 12,000 stock items of precision gears, shafts, speed reducers, magnetic clutches, differentials, instrument plates, tools, and many other associated components. Master Catalog No. 21 also contains prices of all items described. 416 pages. PIC Design Corp., 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 676 on Page 19

Formed Metal Shapes

An illustrated listing of over 500 cold-formed metal shapes for which rolls and dies are on hand is available in Catalog OS-1059. Sections are shown full size. 48 pages. Van Huffel Tube Corp., Warren, Ohio.

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Hydraulic Pumps

Specifications and performance curves for a new line of fixed-angle variable delivery hydraulic pumps are given in Bulletin A5233A. Schematic views of components show the design principle used to vary delivery rate of nine models having rated flow at 3000 psi of 3.26 to 98.6 gpm. Pumps exceed new MIL-P-19692 for service life requirements and contamination tolerance. 6 pages. Vickers Inc., Div. of Sperry Rand Corp., Box 302, Detroit 32, Mich.

Circle 678 on Page 19

X-Ray Techniques

Available as an employee visual-aid, a wall chart shows ten basic x-ray techniques used for industrial quality control and scientific research. A simplified diagram with explanatory notes is shown for each method. 1 page, 11½ x 22 in. Philips Electronic Instruments, 750 S. Fulton Ave., Mount Vernon, N. Y.

Circle 679 on Page 19

Oil Coolers

Catalog 1059 lists complete data and performance on oil-to-air cooling equipment for stationary and mobile installations. Shell and tube oil-to-water coolers are also described. 10 pages. Young Radiator Co., Racine, Wis.

Circle 680 on Page 19

Spherical Roller Bearings

Bulletin 113 describes and pictures five series of quality bearings. Line drawings and close-up photographs demonstrate design features. Tables providing complete dimension and load capacity data are furnished for each series. 16 pages. Hoover Ball & Bearing Co., 5400 S. State Rd., Ann Arbor, Mich.

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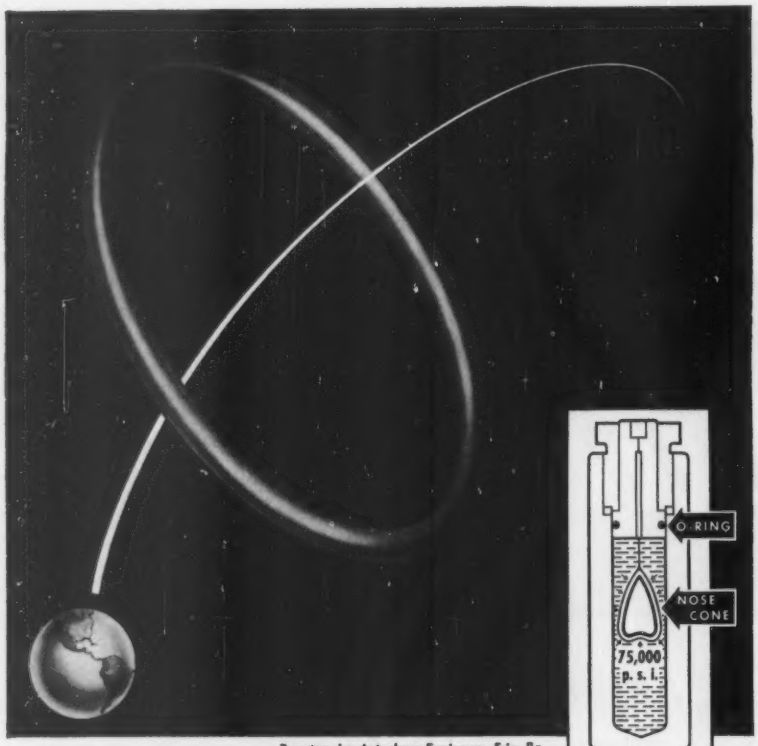

Reactors by Autoclave Engineers, Erie, Pa.

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Time-Delay Relays

Delay times on small electronic time delay relays are changed by an external screwdriver adjustment. Two models cover a total range of 50 milliseconds to 50 sec, and delay can be specified for pull-in or drop-out. Bulletin No. 376-100, Rev. 4/59 covers these as well as factory preset and externally adjustable time delay relays. All are hermetically sealed, use printed circuit construction, and can withstand exceptional shock and vibration. 8 pages. Master Specialties Co., 956 E. 108th St., Los Angeles 59, Calif.

Circle 682 on Page 19

Speed Reducer Package

Bulletin 3100.01 Supplement offers an additional line of standard gear-motor package drives in the lower speed and higher horsepower ranges. The 8E Motoreducer series has high overhung load capacity and covers output speeds from 1 rpm, horsepower capacities to 75. Selection tables, overhung load example, and physical dimensions are included in bulletin. 4 pages. The Falk Corp., Box 492, Milwaukee 1, Wis.

Circle 683 on Page 19

Recording Oscillograph

Recording simultaneously as many as 26 separate items of test data, the versatile Model 5-114 recording oscillograph permits the study of phenomena in their relationship to a common time base and to each other. A complete description of the instrument and its features, along with accessories and a table of galvanometer specifications is given in Bulletin 1500. 16 pages. Consolidated Electrodynamics Corp., Electro Mechanical Instrument Div., 360 Sierra Madre Villa, Pasadena, Calif.

Circle 684 on Page 19

Corrosion Resistance

Corrosion Resistance Chart J-CRC lists over 150 different chemicals and their recommended usage with ductile iron, iron, steel, 316 and 304 stainless steel, Monel, brass, bronze, copper, aluminum, and plastisol plastic. It also shows which gasket materials are needed for various chemicals when Kamlok Quick Couplers are used, and which O-ring materials are needed when swivel joints are used with these chemicals and compounds. 4 pages. OPW-Jordan, 6013 Wiehe Rd., Cincinnati 13, Ohio.

Circle 685 on Page 19

Surface Measurement

A pocket size reference manual contains important excerpts from ASA B46.1-1955 "Surface Roughness, Waviness and Lay," including illustrations. Featured is a conversion chart for changing arithmetical average to rms average. The Surfindicator, a production gage for surface finish control, is illustrated and described. 12 pages. Brush Instruments, Div. of Clevite Corp., 37th and Perkins Avenue, Cleveland 14, Ohio.

Circle 686 on Page 19

THIS NEW QUILL-TYPE AJUSTO-SPEDE® DRIVE

Plus

THIS NEW K-2 CONTROL and PUSH-BUTTON STATION

Red tint indicates adjustable speed member.

Give You Controlled Adjustable Speed from an AC Power Source

in a Compact, Low Cost 3-Unit Drive Package by

DYNAMATIC®

PIONEER IN EDDY-CURRENT EQUIPMENT

Three compact components, the Ajusto-Spede Drive, the K-2 Control, and the push-button station make up this complete drive package which provides controlled adjustable speeds for any application from ½ HP through 7½ HP at 1800 RPM.

Remote wall mounting of the control panel conserves space on the driven machine; the push-button station places vital controls at the operator's finger tips.

Standard control features include on-off clutch control, infinite speed adjustment, constant speed regulation, and jogging. Any of a variety of special features may be easily and economically added to the standard control by the installation of a single resin-encapsulated circuit.

Send for complete information covering design and operation of the new models ACM-903 and 904 Ajusto-Spede Drives. Read how the new K-2 Control provides infinite speed adjustment, on-off clutch control, constant speed control, jogging, threading, cascading, and acceleration control.

Our New Bulletin K-2-159 is Now Available.

EATON®

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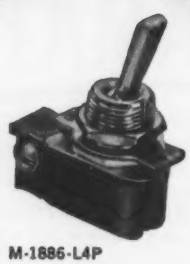
DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Circle 512 on Page 19

precision engineered control switches

designed with brand new features

Keeping pace with design engineers, Circle F offers modern control switches for every possible application. New economies are now possible through the use of standard switches readily modified to meet any particular specification. Circle F's advanced standards of quality-controlled manufacture makes possible assembly-line production of highest quality "custom-made" switches in less time and at lowest costs. Whatever your need, write Department S for fullest information and helpful engineering assistance.



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NEW "PADDLE" HANDLE SWITCH

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NEW THREADED PLUNGER SWITCH
for any cap

L-40

L-52

1885

1903

CIRCLE F's "Fine" Silver Contacts reduce arcing on slow-make, slow-break AC and insure long, dependable switch life.

CIRCLE F MFG. CO.

TRENTON 4, NEW JERSEY • For your wire requirements: Eastern Insulated Wire Corp., Box 591, Trenton, N. J.

Thermal Analog Tubes

A device to measure thermal environments encountered by vacuum tubes, the Thermion tube enables designers or manufacturers to evaluate each socket in electronic equipment packages for possible thermal problems. Technical Report 7-8-9 describes importance and use of Thermion tubes. 4 pages. Research Council Inc., 1062 Main St., Waltham 54, Mass.

Circle 687 on Page 19

Flow Regulators

Savings in weight and space in critical missile and other regulated hydraulic systems are made possible by use of cartridge-type flow regulators. Flow is controlled independent of system pressures or varying back pressures. Engineering Bulletin A-300 contains specifications and application data. 4 pages. Waterman Engineering Co., 725 Custer Ave., Evanston, Ill.

Circle 688 on Page 19

Expanded-Scale Meter Relays

To achieve greater accuracy than that available with a D'Arsonval meter, an expansion network eliminates the part of the scale not needed and expands the used portion. Theory, circuitry, and list of available meters, including specifications are available in a booklet jointly issued by two firms whose combined efforts produced the series of expanded-scale meter relays. 12 pages. Assembly Products Inc., Chesterland, Ohio.

Circle 689 on Page 19

Self-Locking Aluminum Nut

Design of Tru-Lok self-locking nut permits use at 250 and 550 F, provides high strength-to-weight ratio, and excellent reusability with accurate torque control. Nut incorporates a high-strength, spring-temper, stainless-steel wire form in aluminum body. Bulletins 3002 and 3003 list sizes, dimensions, and features for both coarse and fine-thread series. 2 pages. Waltham Precision Instrument Co., 221 Crescent St., Waltham 54, Mass.

Circle 690 on Page 19

Stainless-Steel Tubing

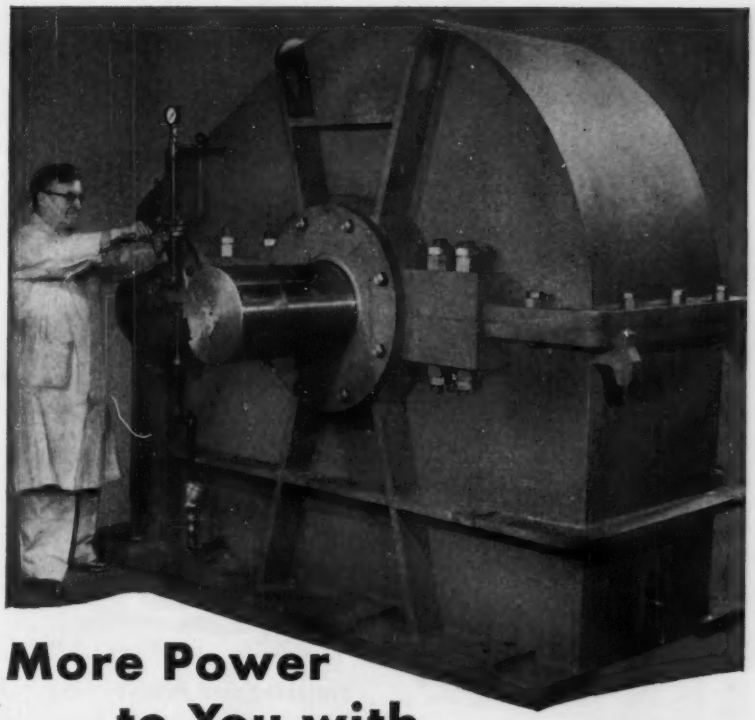
Booklet SS 39, titled "Allegheny Ludlum Stainless-Steel Tubing," gives details on various sizes, grades, design data, and corrosion resistance for both welded and seamless stainless-steel tubing. More than 25 tables are included, along with photographs and other drawings and data. Special section on composite tubing is also incorporated. 34 pages. Allegheny Ludlum Steel Corp., Oliver Bldg., Pittsburgh 22, Pa.

Circle 691 on Page 19

Corrosive-Service Rotameters

Details of materials used in manufacturing rotameters for corrosive applications are given in Bulletin 150. Various types of meter designs are illustrated and described in detail. 8 pages. Brooks Rotameter Co., Hatfield, Pa.

Circle 692 on Page 19



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CONTINUOUS-TOOTH HERRINGBONE GEAR SPEED REDUCERS

The Gear Reducer that's Built-to-take-it—James precision made Herringbone Gear Reducers have been the choice of power transmission designers and engineers for over a half-century. Their proven on-the-job performance—in the steel, coal mining, cement, chemical and other industries—testifies to their operating dependability. Low maintenance costs and the long wearing qualities of the *gears with a backbone* add up to greater efficiency, production and increased profits. James Herringbone Reducers come in all sizes and in a wide horsepower and ratio range, enabling them to handle small and large power transmission installations. Catalog 40-E, containing complete information, is now available. May we send your copy today?

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Manufacturers of All Types of Gear Speed Reducing Transmissions and Cut Gears

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James Gear Sales-Engineers are located in important key centers. Consult your area telephone directory or write Home Office

Circle 514 on Page 19

ABBOTT'S NEW GUIDE to selection of the best Bearing Ball

New Abbott Bulletin AP-1 provides specifiers and buyers with up-to-the-minute information on widely adaptable, totally reliable Abbott bearing balls . . . carbon steel and bronze. Included is important new tabular data on conversion of old Abbott standard ball nomenclature to the new, simplified AFBMA* nomenclature.

Since 1909, Abbott has offered product designers a bearing ball of superior quality and performance . . . a bearing ball that has a deeper case, higher crushing strength, closer tolerance than balls in competitive lines. Bulletin AP-1 tells you why Abbott is the best. Send for your copy today.

*Anti-Friction Bearing Manufacturers Association.

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Send copy of Bulletin AP-1.

NAME_____

TITLE_____

COMPANY_____

STREET_____

CITY_____ STATE_____

Circle 515 on Page 19

HELPFUL LITERATURE

Tungar Bulbs

Complete ratings, design data, weights, dimensions, and typical applications for the ten types of Tungar bulbs now available are given in GE's design and data manual, ETR-2091. The brochure also features descriptive and theoretical data on the use of Tungar bulbs in rectifier circuits to provide noise-free power supplies with low voltage drop and high over-all efficiency. 8 pages. General Electric Co., Electronic Components Div., Owensboro, Ky.

Circle 693 on Page 19

Liquid-to-Gas Equivalents

Handy 8½ x 11-in. wall chart shows at a glance gaseous equivalents of 1 through 5000 gal of liquid oxygen, nitrogen, and argon. Chart shows cubic feet of gas available when liquid is converted to gas. Approximate equivalent number of high-pressure cylinders is also shown. Ronan & Kunzl Inc., Cryogenic Div., Marshall, Mich.

Circle 694 on Page 19

Variable-Speed Pulleys

Variable-speed pulleys are cam-operated type which maintain desired speed even under overload conditions. They range from fractional to 5 hp with speed ratios from 1.75:1 to 2.6:1. Five wide V-belt pulley models with speed ratios of 3:1, and two high-ratio types providing ratios to 7.2:1, are also included. Illustrated Bulletin HL-60 provides information on selection and operating data, horsepower, ratings, dimensions, and representative applications. 24 pages. Lovejoy Flexible Coupling Co., 4932H W. Lake St., Chicago 44, Ill.

Circle 695 on Page 19

Teflon Rings

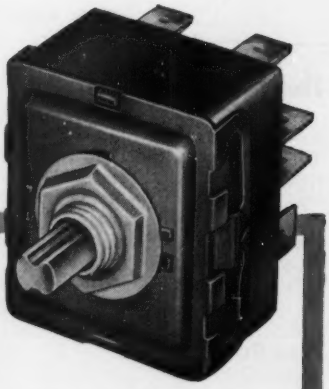
Application of Teflon Glyd rings to hydraulic and pneumatic systems is described in Bulletin S-200. Included are specific data on how the rings reduce O-ring friction and chatter, how their use increases pressure sensitivity of systems, and how they protect and lengthen life of rubber O-rings. Complete selection charts for ID and OD seal Glyd rings in sizes comparable to standard O-ring range are presented. Detailed installation drawings are also included. 6 pages. W. S. Shamban & Co., P. O. Box 1037, Culver City, Calif.

Circle 696 on Page 19

V-Belt Drives

Ultra-V drives reduce over-all drive dimensions by as much as 50 per cent, save up to 25 per cent in weight, and up to 30 per cent in cost over conventional V-belt drives. Bulletin 9102 includes drive-selection tables for stock and nonstock sheaves, horsepower tables, nomograms for service-level comparisons of drive costs, sheave and belt specifications, and information on how to check drive tension. 36 pages. T. B. Wood's Sons Co., Chambersburg, Pa.

Circle 697 on Page 19



"DIAMOND H"

ROTARY SWITCHES

Versatile circuitry of "Diamond H" Rotary Switches is one reason they're found on leading makes of window air conditioners. Single or double pole, with capacities far greater than their size suggests and from two to 12 positions — with or without stop — they are also used to control motor starting and reversing as well as resistive circuits in a variety of other applications.

UL approved ratings range to 25 A. at 120/240 V., to 1 H.P. at 120 V. and 2 H.P. at 240 V., A.C. Bases, however, measure only 1½" x 1¼" x ⅞". Spade or screw terminals. Spindles may be extended to permit ganging of mechanical or electrical controls.

For a quick run-down on "Diamond H" switches, relays, thermostats and other devices, send for a free copy of the "Diamond H" Check List of Reliable Controls.

THE HART MANUFACTURING COMPANY

118 Bartholomew Ave., Hartford 1, Conn.
Phone JAckson 5-3491

Circle 516 on Page 19

Aeroquip PUSH-PULL Hydraulic Couplings Connect and Disconnect Fluid-Carrying Lines

QUICKLY and EASILY

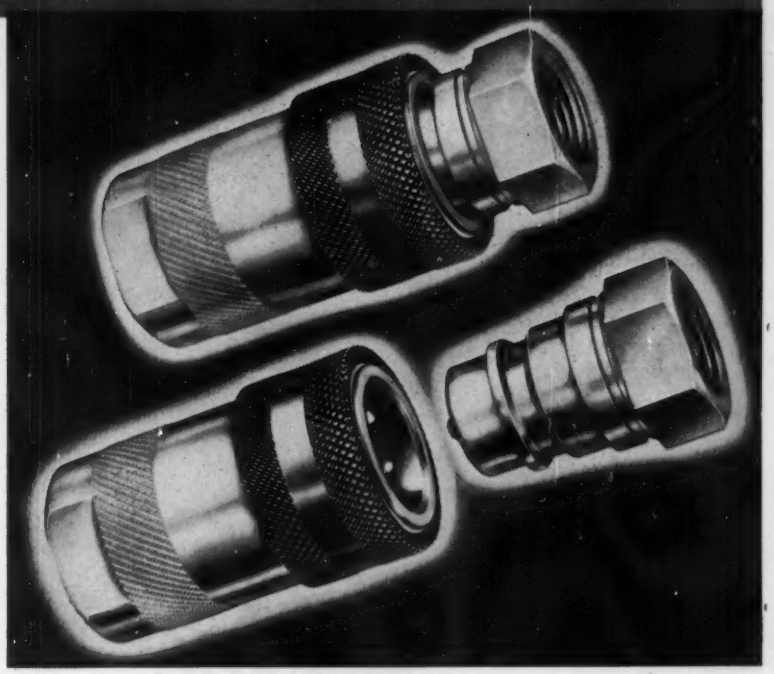
AVAILABLE IN TWO THREAD TYPES FOR INDUSTRIAL APPLICATIONS

5600 Series

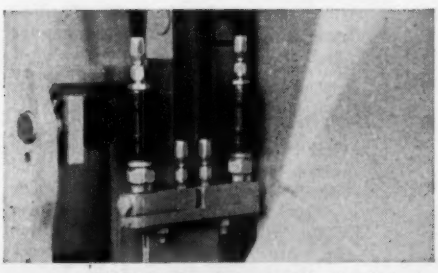
For N.P.T.F. pipe thread connection in ¼" ⅜", ½", ¾" and 1" sizes.

5606 Series

For all S.A.E. straight thread boss (O-ring seal) connections up through 1" tube sizes.



- **Quick Connection and Disconnection**
- **Positive Sealing—Connected or Disconnected**
- **Full Flow With Negligible Pressure Drop**
- **For Working Pressures Up to 3000 psi.**
- **Simple, Rugged Components**



Aeroquip PUSH-PULL Couplings on hydraulic lift truck.

The new Aeroquip PUSH-PULL Coupling is designed for quick, easy connection of hydraulic lines. It features a simplified poppet valve seal that gives long, leakproof service life. The coupling is constructed to protect against entry of dirt into the hydraulic system. Where connect-under-pressure feature is desirable, the 5650 Series PUSH-PULL Coupling is available.

Complete design information on the Aeroquip PUSH-PULL Coupling series is available. Fill in and mail the coupon below for your copy.

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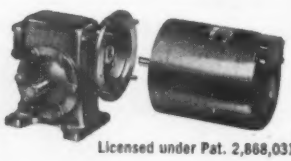
PERFECTION
Flanged & Motorized Worm Gear
SPEED REDUCERS

Perfection Motorized Worm Gear Speed Reducers are available in 956 different combinations, with ratios ranging from 5 to 1 to 60 to 1, and in capacities from 1/6 H.P. to 5 H.P. This line of complete Motorized Reducers is available from stock for immediate delivery. Perfection "C" flange Reducers may be ordered complete with motor or without motor, to be used with a motor of your own choice.

Flanged motor reducers offer the maximum in compactness, rigidity and adaptability. Through the use of standard NEMA face mounted motors, complete interchangeability between motors is provided. Motor maintenance is possible without disturbing the drive and reducer. Motor assembly is fast and positive with no alignment problems.



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Write for your free copy of our new 28 page catalog containing illustrations, charts and tables to help you choose the right Reducer for your particular application. Ask for Bulletin No. M-140.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY **HARVEY, ILLINOIS**

Circle 518 on Page 19

HELPFUL LITERATURE

Plastic Caps and Plugs

Various types of plastic caps and plugs for machine-screw threads, pipe threads, tubing, and propeller-shaft threads are described in Bulletin P-5708. Included are both quality and economy lines. 12 pages. S. S. White Dental Mfg. Co., 10 E. 40th St., New York 16, N. Y.

Circle 698 on Page 19

Pumps and Controls

Full design details and operating characteristics for complete line of hydraulic pumps, fluid motors, and valves are enumerated in Bulletin 220. Each section discusses design and operating characteristics of components involved, with cutaway illustrations in color. Accessory controls for each model are also shown. Tables of typical performance data for individual pump or control units appear throughout the catalog. 72 pages. American Brake Shoe Co., Denison Engineering Div., 1160 Dublin Rd., Columbus, Ohio.

Circle 699 on Page 19

Air Cylinders

Models AVSA and AVSR single-acting, valve-in-head air cylinders are the subject of loose-leaf form AVSA. Features are described, and five types of mounts are shown. Diagrams of the cylinders and mounts are provided. 2 pages. Allenair Corp., 225 E. Second St., Mineola, N. Y.

Circle 700 on Page 19

Industrial Casters

Folder includes illustrations, descriptions, and specifications of 24 different series of swivel-plate and rigid-plate truck casters, ranging in applications from light to superheavy duty. Form 8159 also shows and describes floor truck locks, and eight different types of wheels available are pictured. 4 pages. Faultless Caster Corp., Dept. PR-164, Evansville 7, Ind.

Circle 701 on Page 19

Precision Components

Gear heads, speed reducers, differentials, precision gears, couplings, shafting, and electronic hardware are listed in Catalog 61. Stock items included number over 20,000. 512 pages. Sterling Precision Corp., Instrument Div., 17 Matinecock Ave., Port Washington, L. I., N. Y.

Circle 702 on Page 19

Circuit Breakers

Comprehensive illustrated Speedfax catalog provides extensive information on molded-case circuit breakers, individually enclosed low-voltage power circuit breakers, and engineered products for industrial plant and commercial building electrical distribution systems. Selection charts for circuit breakers list available types, ratings, and accessories. 60 pages. I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.

Circle 703 on Page 19

OZALID NEWSLETTER

NEWS AND IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING

Repro room at I-T-E, showing processing of Information Sheets and standard engineering drawings on Ozalid machines. Simple system saves hours of drafting time for the company.

Short-cut system for custom orders

To help turn out "job shop" work at assembly line speed, the I-T-E Circuit Breaker Company of Philadelphia has devised a simple "Information Sheet" that does away with considerable retracing and revising of engineering prints.

More than 70% of I-T-E orders are for custom-designed equipment using standard components. Revising standard drawings to meet customer specs on each order would saddle I-T-E's engineering department with a nearly impossible work load.

So the Information Sheet is used instead. It's an 8½″ x 11″ tracing form—with printed title blocks—quickly reproduced on the company's Ozalid whiteprinters. Here's how it works:

An order comes in—for 5KV metal-clad switchgear, for instance. A fast freehand sketch of the switchgear is drawn on the Information Sheet. Drawing numbers of standard components and quantity of prints needed are noted on the Sheet.

Then, copies of the Sheet and the required standard drawings are run in the I-T-E repro room. These, with the shop order, go to Manufacturing. When the order is completed, the Information Sheet is returned to the customer file for reference.

This simple short cut with Ozalid whiteprinting saves untold hours of engineering time and gives I-T-E customers faster, more efficient service.

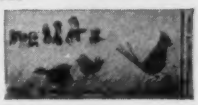
Colors speak louder than words

A simple way to make your security personnel's job a lot easier is to color-code all classified material by using Ozalid sensitized color-copy papers. Colors don't have to be read. Guards can spot restricted or top-secret prints at a glance. Clerks can't make routing mistakes.

To help you devise your own color-coding systems, Ozalid offers papers with eleven image-and-stock color combinations. For example, use black image on yellow stock (instead of traditional blue on white) to code prints of preliminary drawings. Potential uses for color-coding in engineering paper work are virtually unlimited: shop orders, bills of material, spec sheets, change notices, cost estimates, etc., etc.

Like a copy of our new Color-Coding Booklet? It tells how a truly versatile, full-range color-coding system can be yours with as little effort as it takes to run prints that are black on white.

Just write to Ozalid, Johnson City, New York. Booklet No. S-2-18

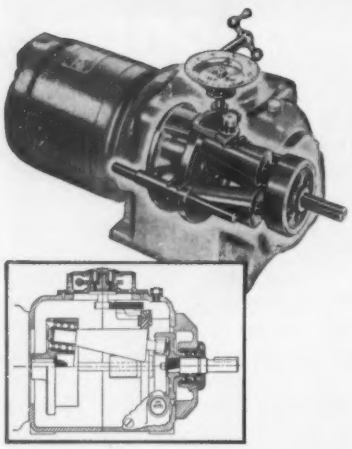


New blue-tint Ozacloth cuts glare, saves eyes

It's bad enough to have *people* glare at you. When your drafting materials glare too, one should take steps. Our research people have—by building a delicate blue tint into our new black-line Ozacloth 101 CZB. It provides excellent contrast between background and dye image—cuts glare, reduces eye strain, makes duplicate originals that are easy to read and work with. Other features? Highest printing speed of any cloth intermediate . . . and a plastic matte surface *on both sides* which accepts pencil, ink or typewriter . . . and keeps sheets from sticking together in files. Write Ozalid at Johnson City, New York, for free descriptive literature on blue tint Ozacloth.

Ozalid—*Division of General Aniline & Film Corp. • In Canada: Hughes-Owens Co., Ltd., Montreal*

INFINITE RANGE EXTREME ACCURACY . . .



Get Both...

WITH

Graham

VARIABLE SPEED DRIVES

The Graham Drive gives extreme accuracy of speed holding and reset from any desired top speed to zero. Range and accuracy are assured through the correct application of metallic traction in the first stage of a compound planetary system.

Three planet roller cones are canted in a carrier to tractionally engage an encircling control ring . . . Pinions on the large ends of the rollers mesh with a ring gear joined to the output shaft . . . Speed is changeable running or stationary . . . Planetary action provides overload protection. The dial permits settings to one part in 4000.

A wide choice of built-in motors, reducers and controls is available in sizes-fractional to 3 HP. Write for full performance data.

GRAHAM EXTRA FEATURES

- **Any desired maximum speed to zero, including reverse.**
- **Straight line extension of a standard motor for true compactness.**
- **Controls tension, proportion, synchronization, etc., from any type of control signal.**

Ask for Graham Catalog 550.

GRAHAM TRANSMISSIONS, INC.
Menomonee Falls, Wisconsin

Circle 520 on Page 19

HELPFUL LITERATURE

Thermocouple Wire

Platinum metals offer high melting points, resistance to corrosion, stability in calibration, and accuracy over a wide temperature range when used for temperature-sensing elements. Brochure, "Noble Metal Thermocouple Wire," provides data on the wide range of noble-metal thermoelements produced. Temperature-millivolt curves, showing working ranges as well, are given for the various thermocouple materials, along with comparisons to certain non-noble combinations. 4 pages. Engelhard Industries Inc., 113 Astor St., Newark, N. J.

Circle 704 on Page 19

Aircraft Bolts

LWB 22 high-strength aircraft bolts provide 220,000 psi minimum tensile strength, yet weigh no more than regular NAS 624 series 180,000-psi bolts. Form 2531 explains how weight saving is achieved, by reducing 12-point wrenching size of head as well as bearing surface diameter. Bolt configuration is shown in close-up photos and design drawings, and design features and specification information are cited. Comparison tables and graph are also included. 4 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa.

Circle 705 on Page 19

Planning Circuitry

Available to help design engineers plan and package circuitry, revised "Quick Order Guide" booklet lists off-the-shelf components used in making up complete electronic systems. Includes terminal-card mounting components, basic chassis components, uni-racks and components, plug-in unit packages, testing and sensing devices, and locking and fastening devices. 20 pages. Alden Products Co., Dept. QOG-149, 117 N. Main St., Brockton 64, Mass.

Circle 706 on Page 19

Belleville Springs

Practical manufacturing tolerances for four grades of springs, and necessary formulas and curves for their design, are given in catalog titled "Belleville Springs." List of materials used in manufacture is set forth, with applications for each material. It includes three pages of text and five pages of curves and formulas. Solon Mfg. Co., South Miles Road, Solon, Ohio.

Circle 707 on Page 19

Two-Piece Bearing

W-retainer bearing provides low-torque bearing reliability for gyros, synchros, small motors, potentiometers, and other applications requiring low torque or extremely smooth operation. Engineering Data Sheet W-1 gives engineering information on such items as performance, torque, dimensions, load capacity, tolerances, calibration, and radial play. 4 pages. Barden Corp., 200 Park Ave., Danbury, Conn.

Circle 708 on Page 19

You can do more things ...and do them better with

STACKPOLE *CeraMAGNET* ®

CERAMIC MAGNETS

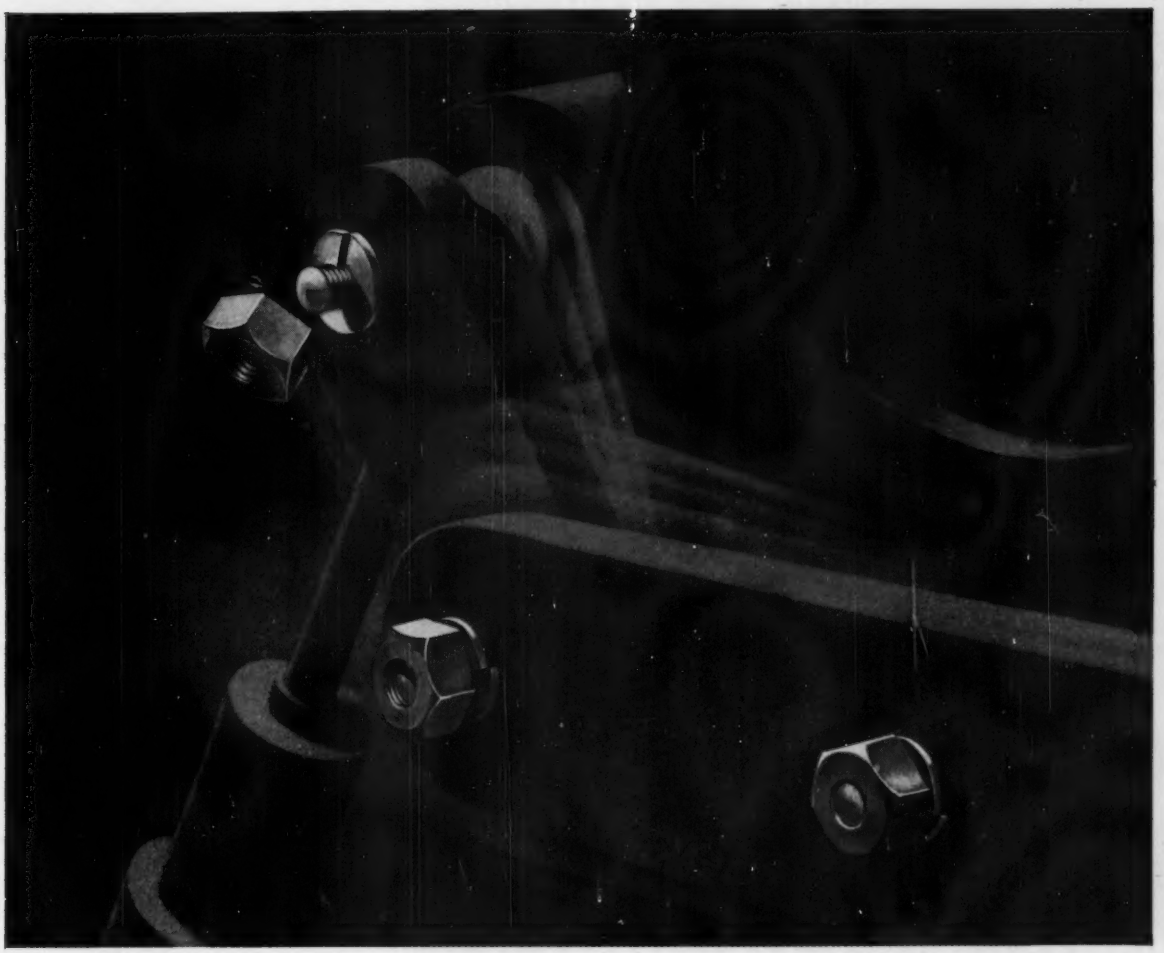
The permanent magnets that are really permanent

Ceramics offer greatest resistance to demagnetization of any commercial magnet material . . . All energy is fully usable—no keepers, pole pieces or auxiliary air gaps needed . . . Can be magnetized before or after assembly . . . Electrically non-conductive . . . Less heating . . . Inert to chemicals and gases . . . Up to 8 or more poles on a single flat face . . . AND MANY OTHER ADVANTAGES.

Write for Ceramagnet Engineering Bulletin RC-11A

STACKPOLE CARBON COMPANY
St. Marys, Pa.

Circle 521 on Page 19



30 SECONDS TO FAILURE!

—*and somebody's reputation is shaking*

When pounding vibration shakes loose common fasteners like these, critical working parts of a product usually fail. When this happens, the reputation of the manufacturer is shaken, too.

Elastic Stop® nuts will not shake loose. Each nut uses the exclusive red nylon locking insert to provide a continuing locking torque which absorbs impact and shock loads and holds under the most severe operating conditions. In the long run, it is exactly this capacity to lick vibration-induced failure that makes Elastic Stop nuts the most economical fasteners you can buy.

Elastic Stop nuts cost only a little more than the combination of fasteners used here. But can you afford the *real* price of any low-cost fastener that fails to provide reliability? For it's precisely this type of false economy that ruins reputations when customers incur costs for repairs, downtime and loss of production. As a matter of fact, the cost of extra field service may wipe out the manufacturer's profits, too.

Detailed photos are available showing exactly how Elastic Stop nuts solve critical fastening problems on rock drills, scrapers, snow plows, off-the-road truck and other heavy equipment. You can see these photos simply by writing to us. Or, we can send you test samples of the fastener sizes you need. Just write: *Dept. 842-24, Elastic Stop Nut Corporation of America, 2330 Vauxhall Road, Union, New Jersey.*

Elastic Stop nuts offer 3 important design advantages:

Precision adjustment at any point on the bolt

Prevent leakage along bolt threads

Nylon locking insert is re-usable 50 times or more

ELASTIC STOP NUT CORPORATION OF AMERICA

Circle 522 on Page 19

actual size

NEW MINIATURE A.C. MOTOR

high output for commercial use

This a.c. synchronous motor costs you only about half as much as its miniature precision counterpart for military applications. In production quantities it is so economical that you can design it into good quality products that now use induction motors. And because you can put this **bigger** performance motor in **smaller** spaces, it gives you a head start in miniaturizing your design at the same time you improve product quality.

Vital statistics: This Type CMC motor has a starting torque of .7 oz. in. and a continuous duty torque of .7 oz. in. at synchronous speed. It is 1¼" in diameter by 2⅝" long, and weighs 6½ oz. The shaft is precision ground stainless steel, supported by ball bearings. The epoxy-sealed design provides good resistance to normal environmental conditions.

If you have hesitated to design with precision miniature motors in the past, now's your chance!

The Globe motor line includes both a.c. and d.c. models. Globe is pleased to work with you to provide the exact motor you need for your commercial, competitive product. Please write for Bulletin CMC. Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio. BAldwin 2-3741.

GLOBE INDUSTRIES, INC.

PRECISION MINIATURE A.C. & D.C. MOTORS, ACTUATORS, TIMERS, STEPPERS, BLOWERS & FANS MOTORIZED DEVICES

GLOBE

Circle 523 on Page 19

Fastener Guide

Illustrated Catalog 5918 is available as a guide to the selection of self-locking nuts suitable for application at temperatures over 800 F. It includes a resume of technical data pertaining to high-temperature terminology and phenomena such as stress rupture, creep, and relaxation strength. Over 50 pages of fully dimensioned drawings of high-performance, high-temperature stop nuts are indexed as to temperature range. 80 pages. Elastic Stop Nut Corp., Dept. H, 2330 Vauxhall Rd., Union, N. J.

Circle 709 on Page 19

Flexible Couplings

Photographs of couplings and installations, diagrams, and tables for each type of coupling comprise main part of Catalog 60. Included are facts on misalignment, dynamic balancing, bore and keyway standards, and how to select a flexible coupling. Line of miniature couplings is incorporated. New style applications and special couplings designed for specific conditions are also shown. 48 pages. Thomas Flexible Coupling Co., Warren, Pa.

Circle 710 on Page 19

Gear-Case Accessories

Small accessories for aircraft gear cases include magnetic drain plugs, drain hose assemblies, electric chip detectors, breather vents, liquid-level sight plugs, observation windows, and filler plugs and caps. Catalog 3-60 provides design data and dimension drawings for tracing. All types and sizes of accessories are listed and pictured. 23 pages. Technical Development Co., 305 S. Chester Pike, Glenolden, Pa.

Circle 711 on Page 19

Welded Construction

"Designer's Guide for Welded Construction," Bulletin 1100.1, contains charts and illustrations providing information on the application of welding symbols and other basic design data on welds. It includes recent revisions in the Standard American Welding Society Symbols. Folder contains a condensed summary of all welding symbols to guide designers. It also includes specification tables on different types of electrodes and additional suggestions for planning better welded designs. 6 pages. Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 712 on Page 19

Two-Way Valves

Series 20 two-way valves for air, oil, water, gas, or chemicals, are for use in operating pressures to 500 psi and with pipe sizes from ¼ to 3 in. Bulletin 91022 supplies specifications, ordering information, outstanding features, and dimensions of each of three types: Pilot operated, mechanical and manual, and solenoid operated. 8 pages. Airmatic Valve Inc., 7313 Associate Ave., Cleveland 9, Ohio.

Circle 713 on Page 19

Circle 524 on Page 19→

LONG LIFE, *THOMSON* "Snap-In"

NYLINERS®

–*BEARINGS of smooth, tough DuPont* NYLON

Low Cost FLANGED Nyliner | Low Cost SLEEVE Nyliner | Low Cost DOUBLE-FLANGE Nyliner

COST LESS to BUY
COST LESS to INSTALL
& ELIMINATE LUBRICATION

Additional Benefits:

- CLOSE FIT
- LONGER LIFE
- EASILY INSTALLED
- LESS SERVICING
- SELF-RETAINING
- RESIST CORROSION
- LOW FRICTION
- RESIST POUNDOUT
- NO FRICTION OXIDATION
- DAMP VIBRATION
- OPERATE IN LIQUIDS
- NON-CONTAMINATING
- INSTANTLY REPLACEABLE
- RESIST ABRASION
- MINIMUM SPACE
- SILENT OPERATION
- LIGHTEST WEIGHT
- REDUCED WEAR

Engineered to Solve Problems . . . Improve Products . . . Reduce Costs!

NYLINER Bearings are a highly engineered thin liner of DuPont Nylon, designed to bring bearing users the many benefits of Nylon as a bearing material by solving most of the limitations surrounding its use. The compensation gap principle assures maintenance of diametral tolerances for precision applications.

Seven Standard Types available from stock. Write for literature and name of your local representative who stocks NYLINER Bearings for immediate shipment.

THOMSON INDUSTRIES, Inc.

DEPT. 4, MANHASSET, NEW YORK

Also— —Manufacturers of BALL BUSHINGS . . . the Ball Bearing for Linear Motions and 60 CASE . . . Hardened & Ground Steel Shafting

STANDS TOUGHEST SERVICE
DRIVES HEAVIEST LOADS

ATLAS

OFFSET SIDE BAR ROLLER CHAIN
PRECISION BUILT...HEAVY LOAD CHAIN

PRECISION CLEARANCES for efficient operation . . . accurate fit and smooth bearing surfaces.

PINS TOUGHENED for shock loads. Precision hardened rollers, bushings and links to stand severe operating conditions.

DETACHABLE ASSEMBLY makes link replacement easy. Chain made up of series of identical links held together with cottered or riveted pins. No searching for connecting link.

BUILT-IN MISALIGNMENT COMPENSATION to allow for sprocket variance. Requires same sprockets as for standard roller chain.

This is the chain to handle heavy loads under extremely difficult operating conditions. Made in sizes from No. 3100 single width to No. 3160-2 double width. For complete details and power transmission advice write or call . . .

ATLAS CHAIN & MANUFACTURING COMPANY
Subsidiary Prudential Industries, Inc.
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GET YOUR COPY OF THE NEW FOLDER ON HEAVY DUTY CHAIN!

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HELPFUL LITERATURE

Resistor Selection

Durable, loose-leaf insert selector chart permits fast determination of values encountered in precision resistor applications. Form Z-44-A gives finger-tip information that eliminates need for solving equations for power and Ohm's Law. Four numbered values—current, voltage, power, and resistance—are arranged on four individual chart axes. With any two predetermined values available, a glance at chart allows direct reading of the others. Data on specifying precision resistors is included on reverse side of chart. 2 pages. Daystrom-Weston Sales Div., 614 Frelinghuysen Ave., Newark 12, N. J.

Circle 714 on Page 19

Weld Fasteners

In addition to complete dimensional information on stock weld nuts, weld screws, special-purpose weld parts and leg levelers, Catalog 60 includes welding information, electrode data and designs, and weld setups for welding individual parts. It also contains an engineering section on welding practices. 49 pages. Ohio Nut & Bolt Co., 33 First Ave., Berea, Ohio.

Circle 715 on Page 19

Precision Gears, Components

Loose-leaf, three-ring catalog bound in leatherette covers lists stock of 32, 40, 64, 72, 96, and 120-diametral pitch gears of various types. Complete data are given for the products. Section on components such as clamps, ball bearings, and shafting is also incorporated. Data section contains general information and engineering tables and graphs. Title of catalog is "Certified Precision Products." Approximately 190 pages, 8½ x 11-in. size. Write on company letterhead to Atlas Precision Products Co., Div., Prudential Industries Inc., 3801 Castor Ave., Philadelphia 24, Pa.

Printed-Circuit Connectors

A special series of connectors, designed for specific applications, is highlight of new catalog which also includes detailed information and specifications on a large variety of standard card receptacles, terminal strips, connectors, and assemblies. 36 pages. Request on company letterhead from Burndy Corp., H. H. Buggie Div., Toledo 1, Ohio.

Micromodule Wafers

Bulletin MMW describes the production of Fotoceram micromodule wafers, using photographic reduction, chemical machining, and heat treating, the end product being a true ceramic, holding extremely accurate dimensions. Tooling is relatively simple for wafers with patterns other than the four stock patterns available from stock. 4 pages. Request on company letterhead from Corning Glass Works, Electrical Products Div., Corning, N. Y.

Circle 525 on Page 19

Use Snap-Tite Valved Couplings and you'll always know when you've stopped the flow!

Use Snap-Tite valved couplings and you'll never have to test lines to see if flow has stopped as you do with conventional valves.

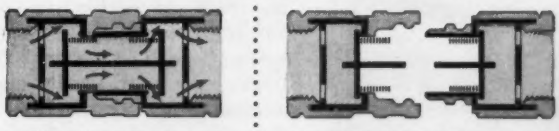
The instant you disconnect the two halves of a Snap-Tite coupling, flow stops . . . and you know at a glance the line is closed. Reconnect and right away full flow begins again.

Snap-Tite couplings take up less space, prevent the possibility of leaking valves, save time and money in installation and maintenance. Ask your local Snap-Tite representative how much you can save by using Snap-Tite couplings.

SIZES: ¼" to 6" in aluminum, brass, steel and 303 and 316 stainless. Larger sizes and other metals on special order.

For more information, write for Snap-Tite Catalog #58. Ask for the name of your local Snap-Tite representative.

TO USE SNAP-TITE VALVED COUPLING:



CONNECT—Full flow instantly

DISCONNECT—Stop flow instantly

★Snap-Tite

ST-59-04

UNION CITY 11, PA.

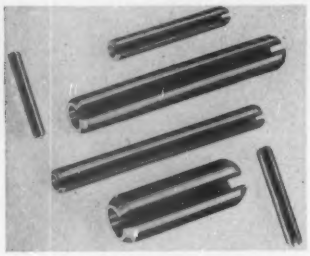
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Tension Pins

for fast, low-cost, pinning applications

Pressure-fitting tension pins are hollow, with a longitudinal slot. Made from highly elastic spring steel, cold rolled, hardened and tempered, they are 40 per cent lighter than solid pins. Outside diameters are predetermined larger sizes than holes to be fitted. Pins compress as they drive into hole, and spring steel exerts pressure on wall of hole for a secure, vibration-resisting fit.



Designed for fast, low-cost pinning applications, pins are available in nominal diameters from 1/16 to ½ in. and up, and in lengths as specified. Two pins can be combined, one inside another, where there is extra-high shear stress or extra-heavy shock load. Pins can be used in steel, cast iron, light alloys, plastics, and porcelain. They can be removed and reused without loss of temper or tension. **John Gillen Co.**, 2542 S. 50th Ave., Cicero 50, Ill.

Circle 716 on Page 19

Pancake Air Cylinders

have molded nylon body material

Pancake air cylinders, using molded nylon as a body material, have been reduced in cost by approximately 60 per cent while maintaining high ruggedness and porosity. Cylinders can be used in corrosive

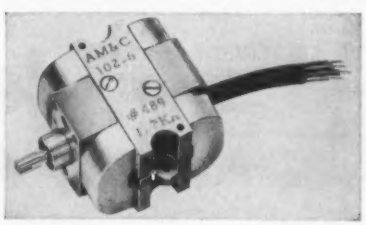
atmospheres. They have withstood over 1500 psi air pressure. Small size and special shape make cylinders suitable for use of air in light-duty applications such as tooling for plastic and fiber machining, metal-working, machine tool set-ups, special fixtures, and transfer-line units. Cylinders are available at present in one standard low-pressure size with 1⅛-in. bore and 1:1 line-pressure ratio. Stroke range is from 0.01 to 0.5 in. Cylinders with 1⅝ to 2-in. bores, and strokes from 0.01 to 1 in. will soon be furnished. **Fabco**, 1231 Main Ave., Cleveland 13, Ohio.

Circle 717 on Page 19

Rotary Torque Motor

has output in form of output shaft rotation

Rotary-output torque motor has absolutely no backlash, end play, or radial play. Output is in the form of an output shaft rotation. Output rotation is ±12 millirad. Pressure-proof O-ring seal can be used around output shaft to isolate torque motor from controlled medium, whether gas or liquid. Motor is available for operation at tempera-



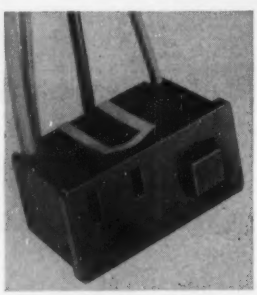
tures to 650 F. Torque sensitivity is quite high, and hysteresis is very low (about 1 per cent). **American Measurement & Control Inc.**, 240 Calvary St., Waltham 54, Mass.

Circle 718 on Page 19

Pushbutton Switch

incorporates grounded outlet

Compact pushbutton switch features snap-in mounting, simplified wiring, and grounded outlet. Low-cost unit is available in black Bakelite. Combination unit is designed for appliance, utility cabinet, and other applications requiring convenient outlet and switch combined in a small space. Unique clip permits fast, snap-in panel mounting for flush installations. Switch is maintained-action, push-on, push-off type, rated at 3 amp; outlet is rated



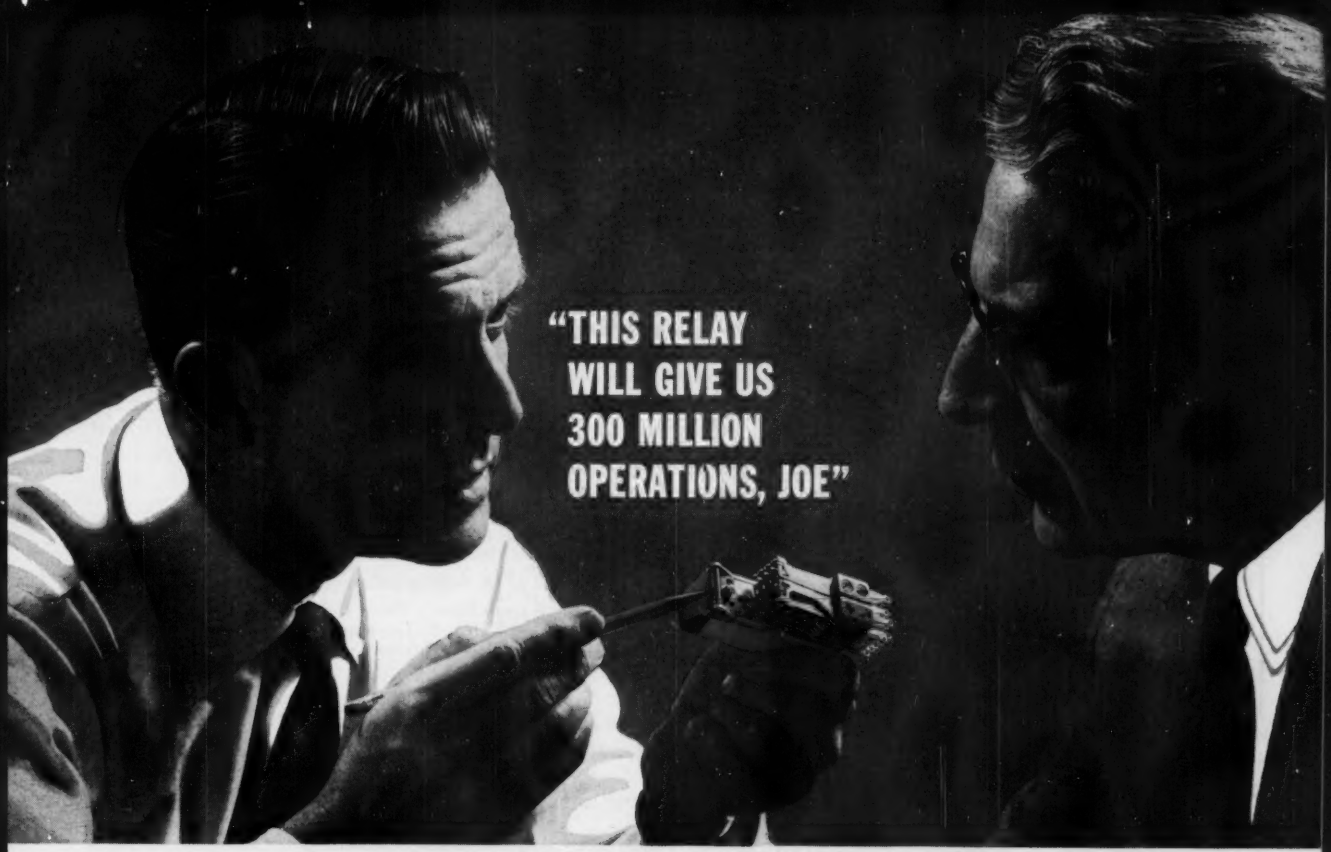
at 15 amp, 115 v ac. **Molex Products Co.**, 9515 Southview Ave., Brookfield, Ill.

Circle 719 on Page 19

Adjustable Slip Clutches

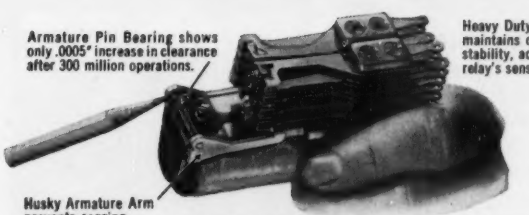
in small envelopes have high torque capacity

Available in sizes from 5/16 to 3 in. diam, adjustable slip clutches are for use in applications with torque from ½ oz-in. to 300 lb-in. Units have custom-built shaft and mounting configurations. Clutch shown is 1-in. diam unit capable of



HERE'S WHY P&B TELEPHONE TYPE RELAYS GIVE YOU

reliable performance over long life


Armature Pin Bearing shows only .0005" increase in clearance after 300 million operations.
Heavy Duty Frame maintains dimensional stability, adds to relay's sensitivity.
Husky Armature Arm prevents sagging or bending.

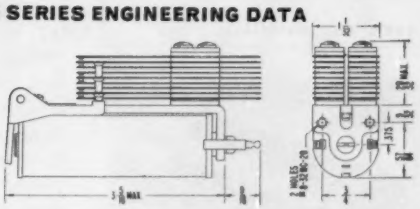
BS SERIES TELEPHONE TYPE

Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations.*

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

BS SERIES ENGINEERING DATA



GENERAL:
- **Breakdown Voltage:** 1000 volts rms 60 cy. min. between all elements.
- **Ambient Temperature:** −55° to +85° C. +125° C available on special order.
- **Weight:** 9 to 16 ozs.
- **Terminals:** Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
- **Enclosures:** Dust covered or sealed

CONTACTS:
- **Arrangements:** DC—up to 28 springs AC—up to 24 springs
- **Material:** ¼" dia. twin palladium. Up to ½" dia. single silver. Other materials on special order.
- **Lead:** 4 amps at 115 volts, 60 cycle resistive
- **Pressure:** 15 grams minimum

COILS:
- **Resistance:** 100,000 ohms maximum
- **Current:** 10 amps maximum
- **Power:** DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
- **Duty:** Continuous
- **Treatment:** Centrifugal impregnation
- **Voltages:** DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes ¾" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.

TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

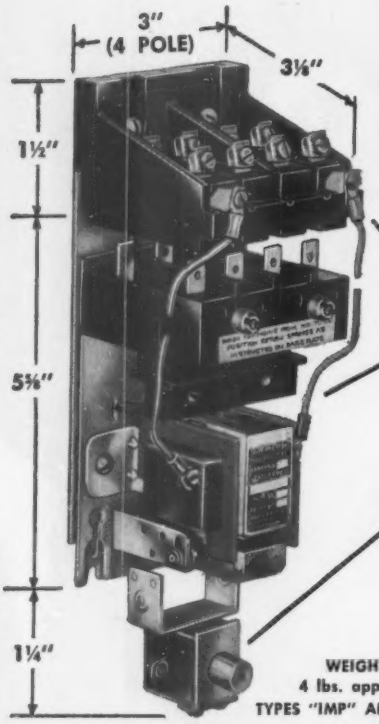
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

Circle 527 on Page 19



HEAVY DUTY RELAYS GREATEST Control Versatility Ever Offered

600 VOLTS AC • 10 and 15 AMPS • 2, 3, 4, 6 or 8 POLES

- **RUGGED and RELIABLE . . .** with exceptional electrical and mechanical life. Simple construction for easy maintenance.
- **OPTIONAL PLUG-IN RECEPTACLE . . .** allows fast replacement of relay *without* disturbing wiring. Minimizes down-time on high-output machines.
- **FAST, EASY COIL REMOVAL . . .** just remove 2 screws, swing coil to front and lift out entire assembly.
- **SIMPLE CONTACT CONVERSION . . .** from normally-open to normally-closed. No tools needed.
- **MOST VERSATILE LATCHING ATTACHMENT . . .** exclusive with A-H. Only attachment that converts in the field from "latch-in" to "latch-out" or "latch in-and-out."
- **AVAILABLE . . .** with AC or DC holding coils.

For free copy of the 8-page Heavy Duty Relay Catalog Section, write to The Arrow-Hart & Hegeman Electric Co., Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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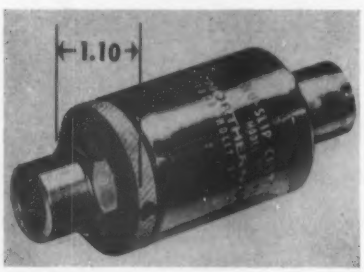
Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 528 on Page 19

ARROW AH HART

NEW PARTS AND MATERIALS



80 lb-in. of torque before slipping. Clutches slip smoothly, quietly, and without galling or chatter. They are made from corrosion and fungus-resistant materials. **Northern Union Inc.**, 1020 Holly Ave., Arcadia, Calif.

Circle 720 on Page 19

Adhesive System

bonds "nonbondable" Teflon to itself and other materials

Designated as PA-746, new adhesive system is supplied in kit form. Available for bonding "nonbondable" Teflon to itself and to other materials, each kit includes a treating agent which prepares Teflon surface, plus two-part bonding agent that cures in a few hours to form a high-strength adhesive joint. Any standard grade of Teflon or other fluorocarbon plastic can be employed. No special training of any type is required to fabricate the parts. **Plastic Associates**, 185 Mountain Rd., Laguna Beach, Calif.

Circle 721 on Page 19

Tungsten-Carbide Balls

in 32 standard sizes have superior hardness

High-precision tungsten-carbide balls are now available from stock in 32 standard sizes: 1/64 through 5/32 in. by 64ths; 3/16 through ½ in. by 32nds; 9/16 through 1 in. by 16ths; 1, 5, and 10 mm. Balls are AFBMA Grade 25, have 0.000025-in. sphericity, ±0.0001 in. basic size tolerance, and 0.00005-in. uniformity per container. Of superior hardness (89-91 Rockwell A), they are used as valve elements handling abrasive materials, as indicator points, in bearings at temperatures

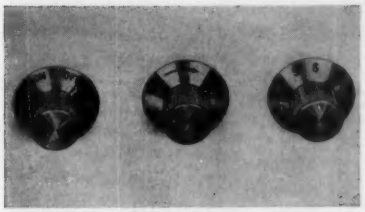
to 800 F, and in other applications requiring maximum wear resistance, smoothness, and strength. Surface finish is 1 microinch. **Industrial Tectonics Inc.**, 3686 Jackson Rd., Ann Arbor, Mich.

Circle 722 on Page 19

Instrument Knobs

of aluminum in six basic sizes

Aluminum precision instrument knobs are precision engraved as shown, or to specific requirements. There are over six basic sizes with over 50 variations. Knobs are precision machined of aluminum, per military specs, and are anodized in either black or clear. Many other



colors are available on request. Available for ⅛ or ¼-in. shaft, and supplied with two Allen-type setscrews, knobs resist high or low temperatures far beyond plastic knobs. **Vemaline Products Co.**, P. O. Box 222, Hawthorne, N. J.

Circle 723 on Page 19

Self-Lubricating Bearing

is completely inorganic

Self-lubricating bearing, Sinitex, is comprised of bronze, molysulphide, and Teflon. Material combines self-lubricating qualities with a low coefficient of friction and, being completely inorganic, lends itself to cryogenic use. Operational temperature capabilities range from −300 to +500 F. Bearing material is available in 6-in. long bar stock in dimensions of 0.3, 0.5, 0.75, and 1 in. OD. Additional sizes to 6 in. OD can be made to specifications. **Booker-Cooper Inc.**, 6940 Farmdale Ave., North Hollywood, Calif.

Circle 724 on Page 19

DC Servo Motors

high-response units range from ¼ through 1 hp

High-response dc servo motors are for industrial applications requiring rapid starts, stops, and reversals. Motors are available in totally enclosed, nonventilated, cast - iron frames in selected ratings in sizes from ¼ through 1 hp. The 1-hp size reverses from +3900 to −3900 rpm in only 0.28 sec. Typical applications include numerical positioning for tracer drives, feed drives and machine tool positioning, radar antenna drives, positioning systems, automatic welding positioners, and contouring systems. High response is provided by very low armature inertia and high accelerating torque. Speed ranges to 400:1, with smooth rotation at low speeds, are accomplished through use of skewed armatures and special field-pole design. Low weight, small size, and flange-mounting design permit direct mounting on machine in any position in a minimum space. **Reliance Electric and Engineering Co.**, 24701 Euclid Ave., Cleveland 17, Ohio.

Circle 725 on Page 19

Miniature Coaxial Switch

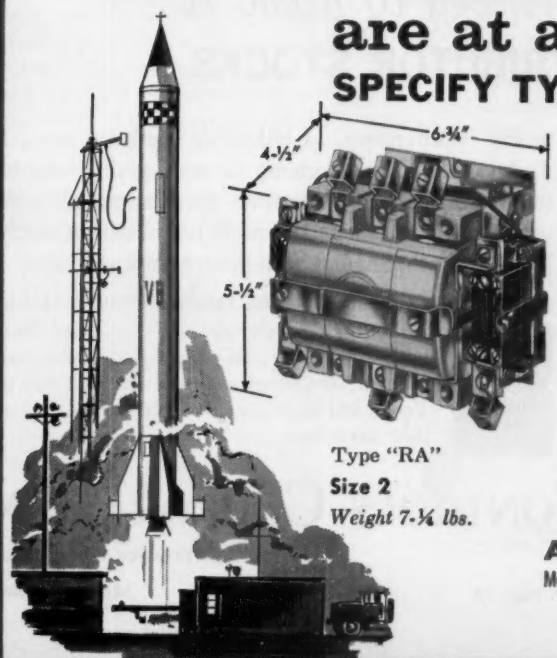
can be used without adapters in miniaturized circuit

Miniaturized coaxial SPDT switch with all electrical and mechanical features of normal coaxial switches can be inserted directly into a min-

MOTOR CONTROLS

Whenever SPACE and WEIGHT are at a Premium...

SPECIFY TYPE "RA" MOTOR CONTROLS



Type "RA"
Size 2
Weight 7-¼ lbs.

Launching, guidance, tracking and service equipment for rockets or guided missiles *MUST* pack the greatest possible performance capacity into the smallest possible envelope. That's why Arrow-Hart Type "RA" Starters and Contactors have been selected for so many rocket and missile projects . . . and so many other applications where space and weight savings are all-important. Far smaller and lighter than conventional types, Arrow-Hart "RA" Controls use advanced design with greatly improved mechanical efficiency to achieve superior performance and dependability. The modern Right Angle operating mechanism insures positive operation and provides increased resistance to unfavorable atmospheric conditions.

For "RA" Data Section, write now to The Arrow-Hart & Hegeman Electric Company, Dept. MD, 103 Hawthorn Street, Hartford 6, Connecticut.

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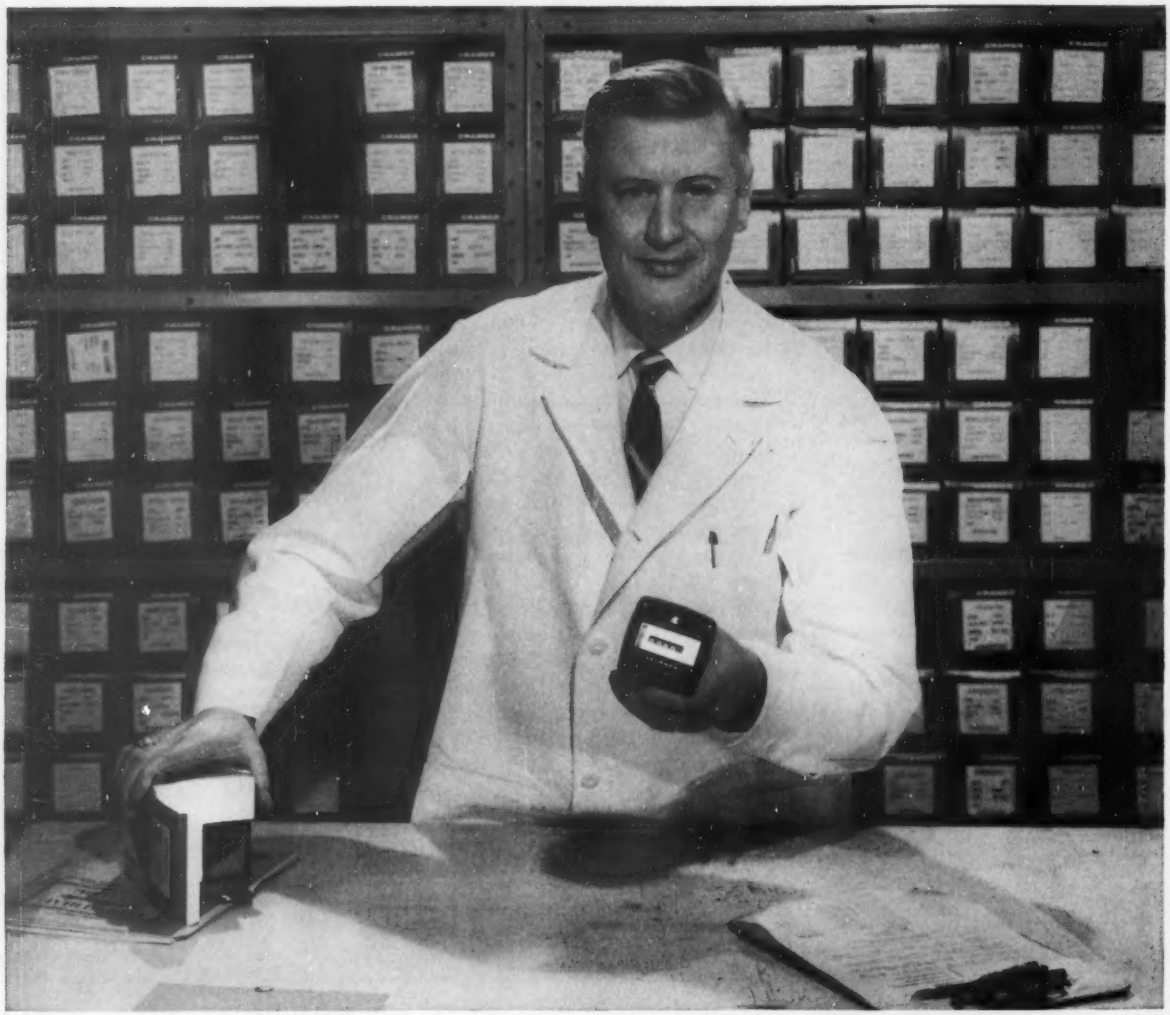
Motor Controls • Wiring Devices • Appliance Switches • Enclosed Switches

Circle 529 on Page 19



Whatever kind of timing control you need, Cramer is most likely to have it

. . . IN 43 LOCAL DISTRIBUTOR STOCKS

For sheer variety of time-control devices, the Cramer line is unmatched. So, next time you're faced with a problem of accurate timing control, remember that Cramer most likely has the answer already in stock. Usually you'll find that your local Cramer distributor can take it right off the shelf. And in exceptional cases, he can get it from the factory in a matter of hours.

Every Cramer product is the result of advanced design and rigid quality control in manufacture. Over the years, each type has been developed to meet exacting requirements, as industry's needs progressed. Today, the "classics" among them are giving trouble-free performance in countless applications all over the world, while models of more recent design neatly handle jobs that hadn't been thought of a year ago.

WRITE FOR YOUR COPY OF THE 18-PAGE CRAMER DISTRIBUTOR CATALOG

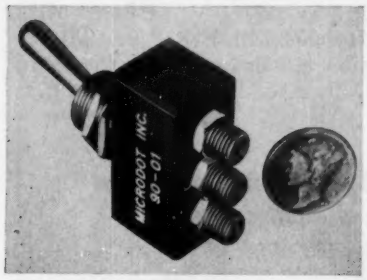
. . . full of facts and figures on standard stock units. And if your problem needs a non-standard solution, let Cramer engineers help you with it. You'll find they have most of the answers at their finger tips.

ELECTROMECHANICAL DIVISION

CRAMER CONTROLS CORPORATION

CENTERBROOK, CONNECTICUT

Circle 530 on Page 19



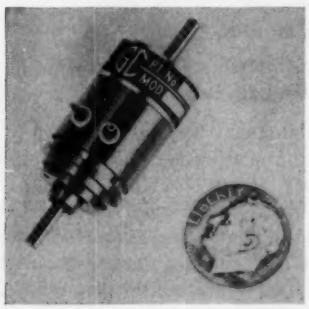
iaturized circuit without adapters. Positive toggle action assures proper switching action, and panel mounting provides easy installation. Mating connectors are available for application at, above, or below 400 mc. Insertion loss of Type 90-01 is 0.5 db at 2 kmc. Voltage rating is 1500 v max (60 cps) and crosstalk is better than 60 db to 2 kmc. Switch weighs only 1¼ oz. **Microdot Inc.**, 220 Pasadena Ave., South Pasadena, Calif.

Circle 726 on Page 19

Clutches and Brakes

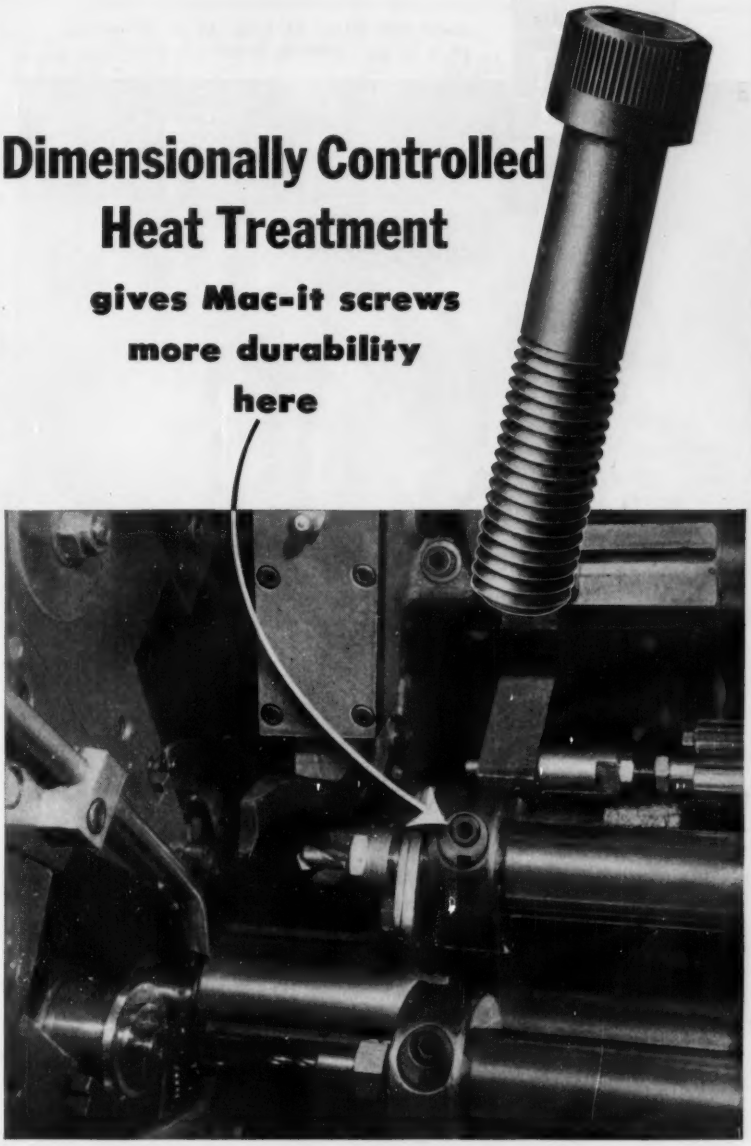
subminiature units have high reliability

Series 6 and 8 precision subminiature clutches and brakes have applications in computer, control, and servo positioning or wherever the size-to-weight ratio is critical and where high reliability is required. Components feature zero backlash, zero endplay, and elimination of slip rings. Clutching and braking are accomplished without angular displacement or axial motion. Precision stainless-steel ball bearings, ABEC 5 or better, are shielded where exposed. Small amount of heat generated by low coil wattage is easily dissipated. Low current requirements and low power consumption require approximately 1.2 w at 24 vdc. Clutches and brakes meet and exceed all applicable requirements of



Dimensionally Controlled Heat Treatment

gives Mac-it screws more durability here



The heat treatment specifications for every Mac-it alloy steel screw are determined by its dimensions as well as its intended use.

At Mac-it, large and small diameters are not run through the heat treating processes indiscriminately. Instead, our metallurgists establish a heat treating cycle for each type and size. This assures that every screw has the proper combination of strength, toughness, ductility and resistance to vibration and shock.

Dimensionally controlled heat treatment is just one illustration of the care which is taken in every step in the manufacture of Mac-it screws. That's why Mac-its *hold tight in a tight place.*

Buy by name from your distributor—buy Mac-it

NEW SPECIFICATION SHEET listing new 1960 Series Socket Screw Industry Dimension Standards. Write for your *free* copy.

Mac-it Parts Co., Dept. 21, Lancaster, Pa.

Mac-it®

MAC-IT ALLOY STEEL SCREWS

Circle 531 on Page 19

ROTARY AIR
GAST
PRODUCTS

Model 3040 Oil-less Air Pump. Up to 20" vacuum, up to 10 p.s.i. pressure. Capacity to 24 c.f.m.

Provide oil-free air with OIL-LESS

GAST rotary vane AIR PUMPS

Model 0240, 0440, 0740 Series Oil-less Air Pumps. Three displacements, from 1.9 to 5.6 c.f.m. Vac. to 15", pressure to 10 p.s.i.

Model 0211-P103-G8X Integral-Motor Oil-less. Up to 1.3 c.f.m. Motor 1/6 h.p. Wt. only 22 lbs. Smaller Model 0406 Oil-less has 1/12 h.p.

Need a pump that delivers absolutely *oil-free* compressed air? A Gast Oil-less Air Pump may be your answer! Built in seven different models — vacuum or pressure — these pumps* run *entirely without oil* in the pumping chamber.

Four carbon vanes lubricate themselves. Ball bearings are grease-sealed for life and separated from pumping chamber by a ventilated space. Air flow can't be contaminated with hot oil vapor.

You can *forget* oiling maintenance problems too! Simple construction delivers up to 15,000 hours' operation without attention, depending on r.p.m. and service conditions. This is a big advantage, especially when your product requires a compressor or vacuum pump mounted in a hard-to-service location.

Widely used on food-packaging, paper-handling, folding and laboratory machines.

Write for full details — request Bulletins 152A and VP-356. GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan.

*Standard oil-lubricated models also available.

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE

GAST ROTARY
"Air may be your answer!"
- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

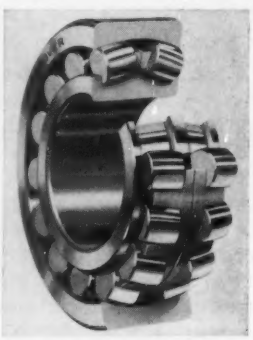
MIL-E-005272, MIL-E-5400, MIL-STD-202, MIL-E-4158, and MIL-E-8189. **Guidance Controls Corp.**, 110 Duffy Ave., Hicksville, L. I., N. Y.

Circle 727 on Page 19

Spherical Roller Bearings

have single spherical outer raceway

Featured on new spherical bearings are raceways and rollers that are finished to afford working surfaces of exceptional, mirrorlike smoothness. Double row of large-size rollers accommodates excessively heavy radial and shock loads. High contact angle provides for substantial thrust capacity in either direction. Bearings utilize a single spherical outer raceway to permit bearing to compensate automatically for shaft misalignment in any direction, either initially or dynamically under load. Accurate roller guidance is assured by a heavy center guide flange between the two inner raceways, asymmetric roller design, and



heavy machined-bronze, land-riding retainers. Complete range of five series and sizes is offered with both cylindrical or tapered bore. **Bearing Div., Hoover Ball and Bearing Co.**, 5400 S. State Rd., Ann Arbor, Mich.

Circle 728 on Page 19

Illuminated Pushbutton

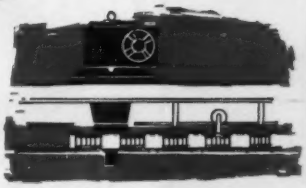
has pressure connectors to eliminate internal wiring

Illuminated pushbutton saves mounting space and installation time by combining in a single device both pushbutton and pilot light. It features pressure connectors to eliminate internal wiring, and terminals are clearly marked for easy wiring.

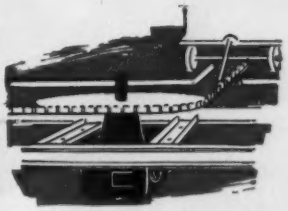
FAST off-the-shelf delivery

MORSE EBERHARDT-DENVER CONVEYOR DRIVES

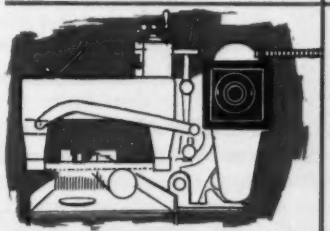
★ **No design limitation . . . up, down, or 90° mounting ★ one-piece alloy cast iron housing ★ high torque capacity ★ single or double reduction gears ★ input ratings from .12 hp to 53.72 hp using double worm reduction or helical worm reduction ★ ratios from 5:1 up to 3600:1—from stock at low factory prices.**



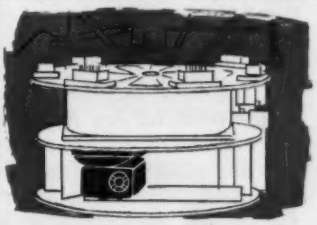
OVERHEAD . . . typical caterpillar or sprocket drives



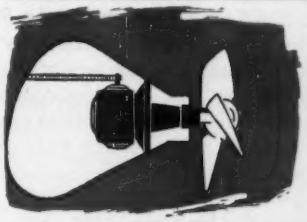
SUB-FLOOR . . . for towline or special equipment



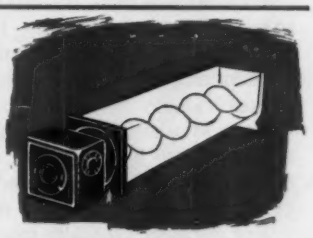
90° MOUNTING . . . for heavy-duty metal saws and machines



VERTICAL . . . base mounting for power turntable machines



SIDE MOUNTED . . . paint, pulp, liquid, or chemical agitators



HORIZONTAL . . . screw conveyors, straight or angular mounts . . . and scores of standard or special uses.

Easy-mount design . . . only 4 bolts

Morse E-D speed reducers lead in limitless applications with utmost ease in mounting. The 4 holes form a perfect square concentric to the output shaft. Unlike most designs, Morse E-D speed reducers feature oversize bearings on wide centers . . . resulting in an overhung load capacity at the end of the output shaft equal to the torque capacity.

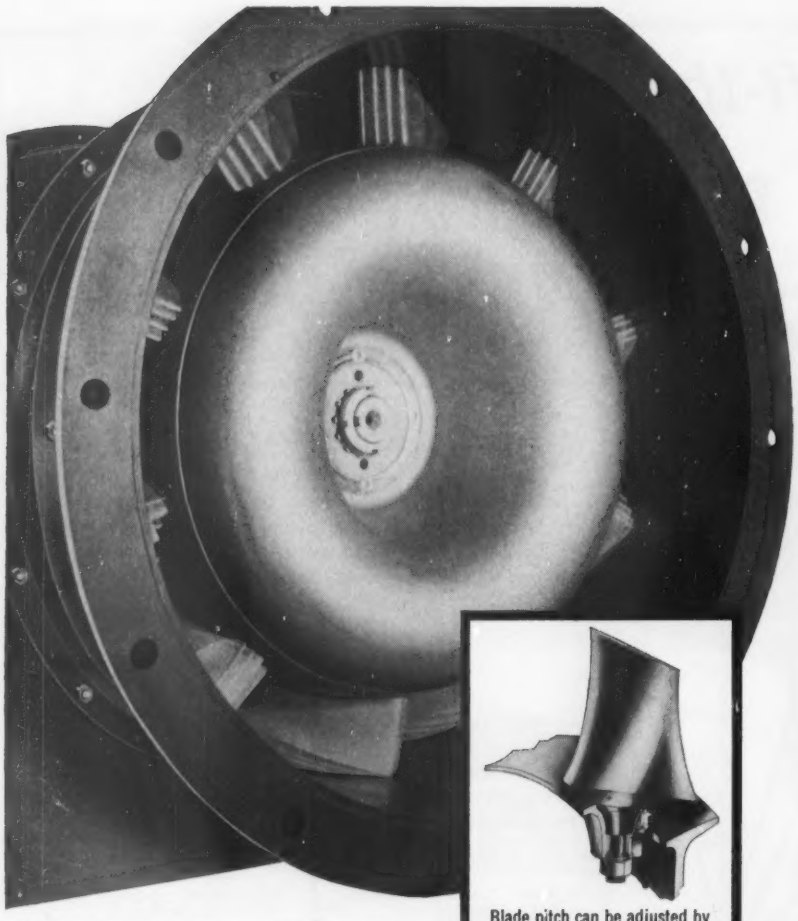
Mounting versatility with the unit's cast-in base makes Morse drives adaptable to conveyors of all types, agitators, screw conveyors, machines, and for any other transmission of power where dependable speed reduction is specified.

You'll find Morse "standard" drives ready for immediate delivery . . . often eliminate the problems of "specials." Check with your Morse distributor, he's listed in the Yellow Pages under "Power Transmission," or write Morse Chain Company, Dept. 6-20, Ithaca, N. Y. for illustrated catalogs. In Canada: Morse Chain of Canada, Ltd., Simcoe, Ontario.

MORSE BW

A BORG-WARNER INDUSTRY

Circle 533 on Page 19



Multiple exposure shows fan blades through the full range of pitch changes.

Blade pitch can be adjusted by loosening one nut, resetting the blade to desired position on calibrated scale, and retightening the nut.

Joy Design Means:

MINIMUM POWER CONSUMPTION WITH VARIABLE FAN OUTPUT

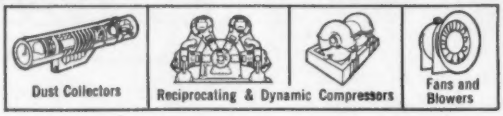
Blade pitch on Joy Axivane® Fans can be adjusted easily. This means that the volumetric output of Joy fans can be varied by as much as ± 20% without any sacrifice of fan efficiency, and therefore with minimum power consumption. The fan motor runs at its most efficient speed, regardless of the fan output, and there are no efficiency losses such as are encountered with dampers and variable inlet vanes.

Even at full load, Joy Axivane Fans are more efficient than propeller, tube-axial and centrifugal fans. The direct drive achieved by mounting the motors inside the fan housings eliminates drive losses, and the vane-axial design gives maximum aerodynamic efficiency. Mounting the motors in the housings also makes the Joy Axivane Fans more compact, and less costly to install.

Fans available range from types which weigh as little as a pound and have a diameter of a few inches, up to some which weigh tons and have diameters up to eight feet. If you need spot cooling, area ventilation, or any movement of air, Joy can supply the most efficient answer.

For complete information, write for Bulletin 1198-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

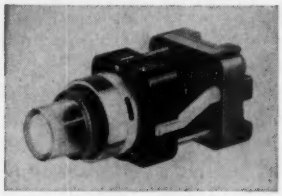


JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 534 on Page 19



Pushbutton has same single-hole mounting as other oiltight units. It is available with button guard to prevent accidental operation. Full range of voltage ratings and choice of six color caps provide added versatility. Contacts are rated for heavy-duty service. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis.

Circle 729 on Page 19

Metalized Mylar Tape

has improved adhesive backing

Mirro Brite Mylar tape is a highly polished, metalized plastic laminate ranging in widths from ½ to 1 in., spooled into a roll approximately 100 yd long. Metalized plastic material is backed with an improved high-tack coating of pressure-sensitive adhesive for easy application to all smooth, flat surfaces. **Coating Products Inc.**, 101 W. Forest Ave., Englewood, N. J.

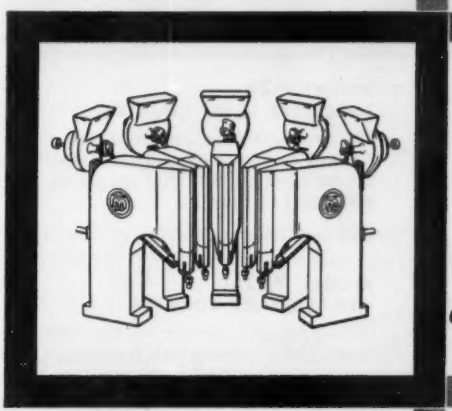
Circle 730 on Page 19

Cable-Connector Boot

prevents penetration of moisture

Zipboot is quickly and easily wrapped around any connector terminating a cable or assembly cable, then sealed with ZT sealer. Made of 105-deg vinyl with a shrinking factor of approximately 30 per cent, unit shrinks to a snug fit over connector and jacket of cable. When ends of boot are

NEW "BUILDING BLOCKS" ... for automatic riveting

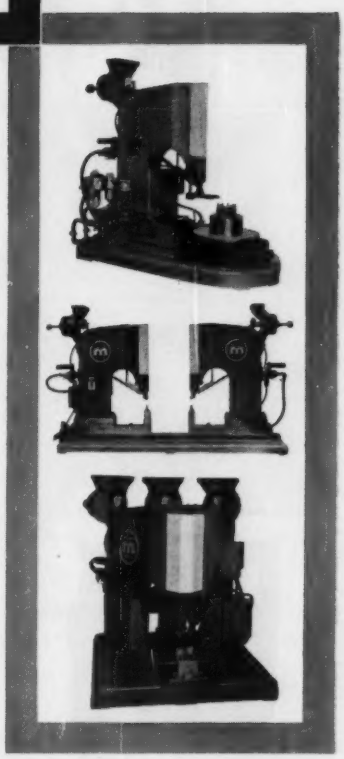


Milford's Models 56 and 57 offer unlimited flexibility in automatic assembly

The narrow wedge shape of Milford's new air-actuated riveters permits unusually close riveting. Both models can be combined with sliding-fixtures, indexing tables or similar attachments to give greatest flexibility of assembly. Air-operated toggle action assures fast and safe action. Model 56 handles tubular rivets from ⅛″ diameter x ⅝″ length; Model 57 from 3/16″ diameter x 3/4″ length.

Group these new "Building Blocks" to suit your own production needs. Use them singly, in pairs, in threes, fours or even fives. Multiple riveting is the newest answer to reducing production costs.

For more new ideas, tips and technical data on tubular rivets and rivet-setting machines, ask your Milford Representative for a look at Milford's new MANUAL OF MODERN RIVETING PRACTICE.



THE MILFORD RIVET

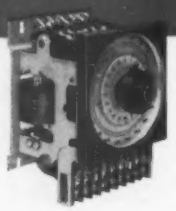
MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNSYLVANIA
ELYRIA, OHIO • AURORA, ILLINOIS • NORWALK, CALIF.

Circle 535 on Page 19

Count Control
COMPONENTS
FOR AUTOMATING INDUSTRIAL PROCESSES

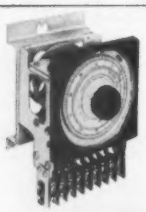
featuring adjustable count · automatic reset · 10 ampere switches



model HZ4
MICROFLEX RESET COUNTER

Use to control an operation for a preset number of counts. Has spring reset to "0." Dial ranges 19, 400 and 1,000 counts.

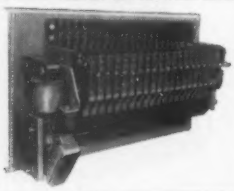
Ask for bulletin 720.



model HZ200
ADD-SUBTRACT COUNTER

Add Subtract counter — operates from ADD pulses which trip switch at maximum limit — and SUBTRACT pulses which trip switch at "0" limit.

Ask for bulletin 740.



model MT
STEP SWITCH

Use for sequence control from pulses — 19 contacts — 60 cycle coil-break out cam lugs.

Ask for bulletin 780.

model HZ6
MICROFLEX REVOLUTION COUNTER

Use to control an operation as a function of mechanical movement — drive shaft can be mechanically connected to machine, spindle, conveyor, etc.

Ask for bulletin 730.

model HM
MULTIFLEX *(Multiple Circuit)* TIMER

Use for sequence control of 1 to 7 circuits. With shaft drive for mechanical connection to an external drive mechanism.

Ask for bulletin 130.

Write us regarding your count problem. Services of Sales Engineers in 25 district offices are available without obligation. Address Dept. MD-260.

EAGLE SIGNAL COMPANY
A DIVISION OF THE GAMEWELL COMPANY
MOLINE, ILLINOIS

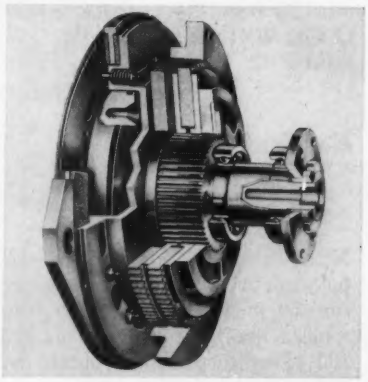
MANUFACTURERS OF THE MOST COMPLETE LINE OF INDUSTRIAL TIME-COUNT CONTROLS

properly sealed to connector shell and cable jacket, unit prevents moisture from penetrating to interior of back shell. Boot virtually eliminates need for elaborate finishes to prevent corrosion and provides resistance to acids and other harmful agents. **Zippertubing Co.**, 752 S. San Pedro St., Los Angeles, Calif.

Circle 731 on Page 19

Air Friction Clutch-Brake

is automatically synchronized



Combination air friction clutch and brake is suited for many OEM applications where controlled single or multiple cycling within a wide range of speed is desired. A single, automatically synchronized, fast-acting, air-operated unit combination is adaptable for mounting on crank, cam, or driveshaft for flywheel or geared application. It can be used with flywheel, gear or drive-spider and mounted outboard or between bearings. Pressure plate acts as both a clutching and braking member. Air pressure moves plate to engage clutch discs in one direction, and spring pressure moves it in opposite direction to apply brake as air exhausts. Absolute minimum travel assures fast action in both directions. **Minster Machine Co.**, Minster, Ohio.

Circle 732 on Page 19

Silicone Rubber Tubing

for use at temperatures from −85 to +225 C

Flexite SR silicone-rubber extruded tubing exhibits outstanding flexibility, retaining elasticity after long exposure to temperatures from −85

SPICER RUBBER ELEMENT SHAFTS CAN HELP YOU SOLVE YOUR TORSIONAL RESONANCE PROBLEMS

If you are faced with the problem of torsional vibration from impulses within the operating range, Dana engineers may be able to help you solve your design problems.

Spicer resilient propeller shaft assemblies have been used successfully for years in rapid transit cars, street cars, engine dynamometer, truck, bus, earthmover and passenger car applications to solve difficult torsional problems.

Spicer rubber-cushioned shafts make it possible for design engineers to "tune out" the vibration and thus produce commercially acceptable installations.

Spicer rubber-cushioned propeller shafts offer these additional advantages:

1. The torsional flexibility limits the effect of high impact loads resulting from rough shifts and other sudden torque changes.
2. The cushioning effect prevents clatter, rattle, and backlash noises.
3. Increased life of bearings, gear teeth, splines, and other components due to the reduction of high impact and torsional loads.
4. Reduction of noise transfer.
5. Axial flexibility to cushion forces resulting from length changes.

Product knowledge and years of experience are available to you through Dana engineers to help solve your torsional problems. Contact them today.

International 295 Payscraper, equipped with a Spicer rubber element shaft, at work on the Interstate Highway System.

DANA Spicer

DANA CORPORATION

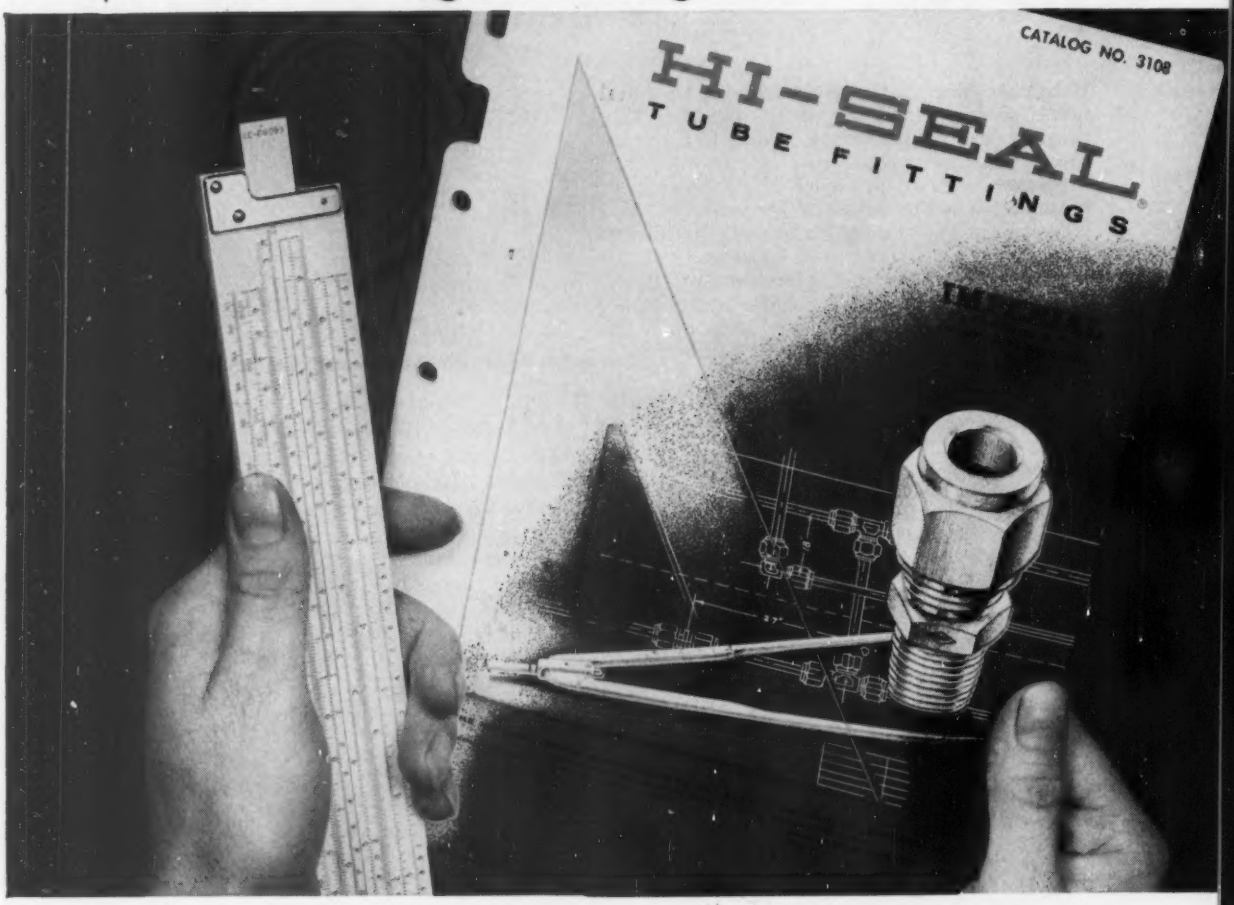
Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters Powr-Lok Differentials • Gear Boxes • Forgings Axles • Stampings • Frames • Railway Drives

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario

Circle 537 on Page 19

IMPERIAL
Engineering and Data File



Your slide rule or this New Hi-Seal Tube Fitting Catalog...

YOU'LL WONDER WHICH ONE HELPS YOU MOST!

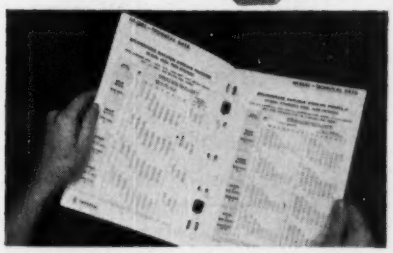
Just off the press! A working handbook for every man concerned with tubing and fitting circuitry. Published by the company with a habit of leadership.

Leading hydraulic and pneumatic engineers, when asked to study advance proof copies of Imperial's new Hi-Seal Catalog, came back with comments like these: "It's a reference manual" . . . "The kind of material I've had to dig up for myself, until now, from several reference sources" . . . "Make sure I'm on your list for a copy as soon as they are available."

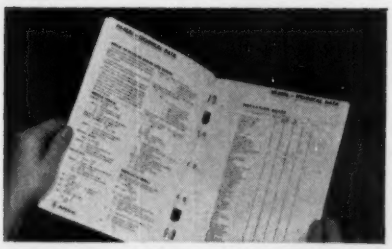
The new Imperial Catalog of Hi-Seal tube fittings contains data, charts, laboratory tests, and formulae on corrosion, vibration, temperature, pressure and vacuum, flow and velocity — vital statistics in hydraulic and pneumatic tubing circuitry design. And it describes the complete line of Imperial Hi-Seal Tube Fittings — *industry's most complete line,* based on a single-design concept, that meets all tubing circuitry requirements. All items in this catalog are stock items and are priced as stock items.

THE IMPERIAL BRASS MANUFACTURING CO.
Dept. MD-20, 6300 West Howard Street, Chicago 48, Ill.
In Canada: 18 Hook Avenue, Toronto, Ontario

How Imperial's new Hi-Seal Catalog helps you solve these problems:

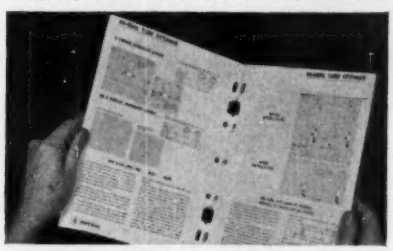


SUPER-HIGH PRESSURES. At your fingertips: five pages of recommended maximum working pressures for a variety of tubing materials, from minor to 150% surge with a safety factor of ten, including Braze-Seal Fittings, the first and only make and break joint for extreme pressures and temperatures.



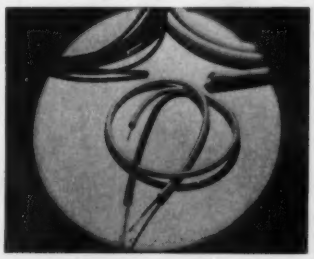
CORROSIVE ATMOSPHERES. Engineering Data: Comprehensive chart rates 140 fluids — from sour gasoline to oxalic acid — and the effect each has on six stainless alloys, brass, copper and aluminum.

Also covered: formulae for calculating surge pressures, tube bursting pressures, Saybolt viscosity, Reynolds number, Harris formula, and others.



SPACE LIMITATIONS. Pages of facts, diagrams, sample systems, showing how Hi-Seal's unique design concept — throughout the complete line — can produce layouts that are more compact, save space, save time, save tubing.

Get your copy of the new Imperial Hi-Seal Tube Fitting Catalog now. Tell us which type of fitting you are most interested in — we'll send you a free sample.



to +225 C. It has excellent tensile strength, elongation, tear strength, resistance to corona, oils, and weathering. Tubing withstands short-term temperatures to 315 C, and is rated for continuous use at 200 C. **L. Frank Markel & Sons**, Norristown, Pa.

Circle 733 on Page 19

High-Temp Epoxy Plastic

for casting, adhesives, and laminating

Epoxy novolac plastic, D.E.N. 438, combines the useful physical and handling properties of conventional epoxies with the high-temperature performance of phenolic resins. Temperatures above 400 F can be handled. Applications include adhesives, structural laminates, prepreg laminates, filament-wound structures, tools, castings, printed circuit board, and electrical insulation. Coating applications are being investigated. **Dow Chemical Co.**, Midland, Mich.

Circle 734 on Page 19

Air-Control Valve

controls single-acting spring-return cylinders

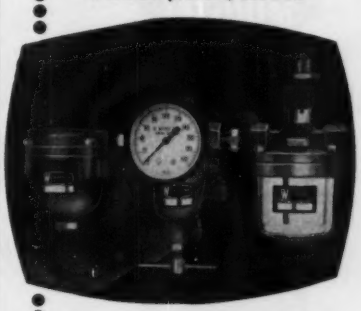
Low-cost valve is available for on-off control of clamp-type and other single-acting, spring-return cylinders. Compact design for use in tight places permits it to be installed readily in any place in the

WILKERSON SAVES SPACE for Machine Designers

HUNDREDS of OEM users have proved that Wilkerson provides the finest miniature units by any comparison

"WILK-O-MATIC" FILTER

- Automatic drain.
- Up to 40 CFM.
- Removes 5 micron particles.
- Maximum pressure, 300 PSI.



"DIATROL" REGULATOR

- Large flows.
- 3 outlet ports.
- Tamper proof adjustor available.
- Non-chattering—self-relieving.
- Maximum pressure 250 PSI.
- 0-50 or 5-125 PSI ranges available.

"ATOMIZER" LUBRICATOR

- Up to 75 CFM.
- Metal or transparent bowl.
- Tamper proof adjustor available.
- Site-Flo Gauge and 2 fill holes.
- Fill without shutting off air.
- Maximum pressure 250 PSI.
- Starts lubricating at ¾ CFM.

WILKERSON MINIATURE

Units available in Combinations or Singles; metal or plastic bowls with manual or automatic drains.

Get detailed specifications.
WRITE TODAY

WILKERSON CORPORATION

Dedicated to keeping the NEW in pNEUmatics

1646 West Girard
Englewood, Colorado

Circle 539 on Page 19

HUCKBOLT®

YOUR BEST FASTENER BUY

INSTALL UP TO 30 PER MINUTE!

- POSITIVE MECHANICAL LOCK.
- EXCELLENT PULL-TOGETHER, HIGH TENSILE PRELOAD.
- HIGH SHEAR AND TENSILE STRENGTH.
- NO LOOSENING OR STRIPPING.
- BROAD BEARING AREAS.
- UNIFORM CLINCH.
- AMPLE GRIP TOLERANCE.
- EASY REMOVAL WITHOUT WORK DAMAGE.
- 3/16" TO 3/4" DIA., GRIPS TO YOUR NEEDS.

SAVE UP TO 70% INSTALLED COST!

HEAD STYLES

The versatile Huckbolt fastener can show you worthwhile savings over most other fastening methods.

These modern, efficient fasteners are available in diameters, grips, headstyles and metals to meet your requirements.

Lightweight, easy-operating Huck power or hand tools can install these fasteners with absolute uniformity up to 30 per minute in the hands of one unskilled operator.

Your Huck fastening engineer will gladly help you.

HUCK MANUFACTURING COMPANY

2480 Bellevue Ave. • Detroit 7, Mich. • WAlnut 3-4500

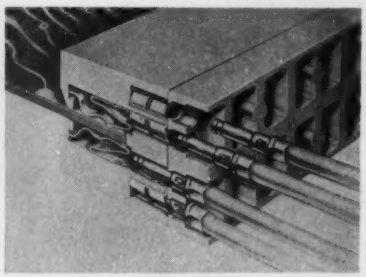
line, on cylinder itself, or on machine in multiple applications. Foster Mfg. Co., 2850 Gravois, St. Louis 18, Mo.

Circle 735 on Page 19

Printed-Circuit Connector

has bifurcated, undulating-spring design

Edge-On printed-circuit Hyfen is an edge-type printed-circuit connector for applications demanding high reliability. It features a bifurcated, undulating-spring design which assures multipoint contact. Small, lightweight connector uses crimp-type, snap-in tips with insula-



tion grips to eliminate any need for insulating sleeves. Tips accommodate combinations of wire sizes as well as single wires. Closed-entry face on board side completely protects spring and self-aligns warped printed-circuit boards. Design of connector allows low board insertion and withdrawal forces. Omaton Div., Burndy Corp., Norwalk, Conn.

Circle 736 on Page 19

Solderless Terminals

for temperatures from −40 to +250 F

Avikrimp solderless electrical terminals are reinforced by a seamless, annealed, tin-plated brass sleeve permanently attached over regular terminal barrel. Crimped in same operation as barrel, skirt part of sleeve permanently grips wire insulation, preventing creep. Permanently attached nylon insulating sleeve extends beyond metal support sleeve. No extra insulation is necessary. Operating temperature range for continuous duty is from −40 to +250 F, and for intermittent duty to 350 F. Sleeve is color coded for wire range. Ter-

Ever see anything so versatile as LAMINUM®?

Generally, laminated shims of LAMINUM are custom stamped to blueprint specifications. Because the laminations are so easily p-e-e-l-e-d to bring the shims down to desired thickness, LAMINUM shims are used universally on assembly lines where they save time and cut costs.

But occasionally you run into a special situation —the need for a shim of *varying* thickness, for example. LAMINUM solves that problem with cost cutting ease. As illustrated, the shim is scored into quarters. Then layers are p-e-e-l-e-d from the quarters so as to come up with varying thicknesses to correspond with variations in the job at hand.

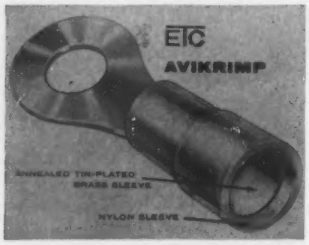
That's LAMINUM! It's fast. Practical. Precise. No need for stand-by equipment. No machining. No grinding. No counting. No stacking. No miking. And no grit between layers—ever.

For quick estimates and service, send your prints to the Laminated Shim Company, Inc. • West Coast Sales and Service 600 Sixteenth St., Oakland 12, Calif. • Home Office and Plant 1202 Union St., Glenbrook, Conn.

LAMINUM is the registered trade name for Laminated Shims with layers completely surface bonded to look and act like solid metal. Design Folder No. 3 contains all facts and engineering data. Send for it.

IN BRASS • MILD STEEL • STAINLESS • ALUMINUM . . . WITH LAMINATIONS .002" OR .003"

Circle 541 on Page 19



minals are available in all tongue types. All standard stud sizes and basic dimensions are available. Terminals feature standard ¼-in. min barrel length that eliminates squeeze-outs and shearing. ETC Inc., 990 E. 67th St., Cleveland 3, Ohio.

Circle 737 on Page 19

Silicon Transistor

has extremely rapid switching action

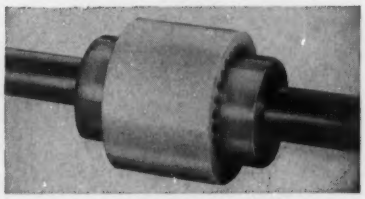
Avalanche Mode silicon transistor has average turn-on time of 4 millimicrosec (0.000000004) while switching 40 w peak power with average power dissipation of only 250 mw. The 2N1468 transistor employs JEDEC TO-5 case with JEDEC E3-44 base. It is expected to have important applications in computers, sampling oscilloscopes, klystron pulsing, and other advanced equipment where switching capacity of transistors limits speed and efficiency of equipment itself. **Semiconductor Div., Raytheon Co.,** 215 First Ave., Needham Heights, Mass.

Circle 738 on Page 19

Nylon Gear Couplings

need no lubrication

Series J gear couplings, with hubs and sleeves made of high-strength, stress-relieved nylon, are designed for direct drives with small integral-hp and fractional-hp motors. They have been tested for static torque of 1100 lb-in., more than ten times recommended operating torque of 100 lb-in. Hubs are bored for shaft sizes of ⅜, ½, ⅝, and ¾ in., and are locked in position on shafts with two set screws spaced 120 deg



apart. Two larger sizes also have keyways 3/16 x 3.32 in. in size. Couplings are compact, with over-all length of 2-9/32 in. and sleeve OD of 1-15/16 in. **Waldron-Hartig Div., Midland-Ross Corp.,** P. O. Box 791, New Brunswick, N. J.

Circle 739 on Page 19

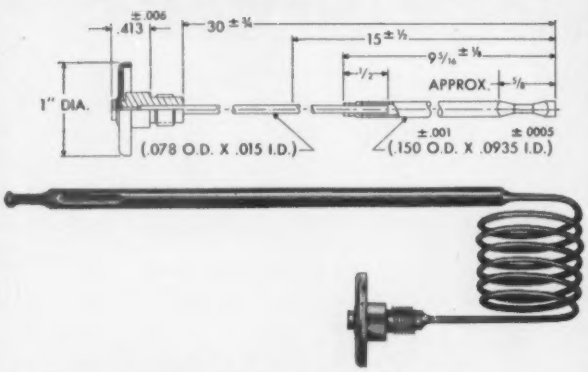
Multipurpose Oil

has temperature range of 40 to 350 F

Anderol L-456 is a multipurpose oil for gears, slides, bearings, and precision parts. Featuring good extreme-pressure qualities, penetration, compatibility with ordinary lubricants, and long life in general-purpose applications, medium-heavy diester oil has over-all temperature range of 40 to 350 F. It has a low

TEMPERATURE SENSOR

ACCURATE, NO-DRIFT CONTROL FOR APPLIANCES SOLVED BY ROBERTSHAW DIASTAT® ASSEMBLY

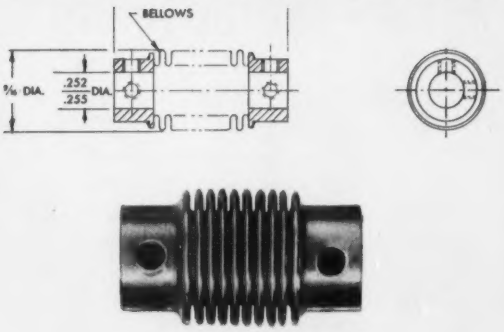


Temperature sensing elements like this one for a range oven control offer permanent accuracy with no drift, consistent calibration, no resetting, long life and savings in space, weight and unit cost. Ambient temperature sensing devices are unnecessary in most applications. Typical stroke is .035″ for a 1″ diameter stainless steel diaphragm. Ideal for sensing temperatures up to 650°F. All units are custom engineered and delivered as pre-assembled "packages," tested and ready for mounting. WRITE FOR BULLETIN N-602

Circle 542 on Page 19

FLEXIBLE COUPLING

ELIMINATE BACKLASH, END-PLAY! ABSORB VIBRATION, SHOCK WITH ROBERTSHAW FLEXIBLE COUPLINGS



Servomechanisms, instruments and similar drive and control systems are the big users of these small, flexible units. Ideal for guarding against misalignment friction and bearing wear problems. Save space and weight. Cut down noise. Simplified design utilizes seamless metallic bellows, in choice of several metals, connected to two hubs. Sizes from 13/32″ O.D. Stock sizes accommodate shafts from ⅛″ to ½″. Other sizes custom-engineered. WRITE FOR DATA SHEET N-802

Circle 543 on Page 19

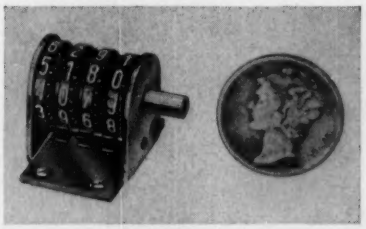
evaporation rate, viscosity index of 174, and excellent resistance to sling-off, drip-off, and wipe-off. Oxidational stability is excellent. Oil is available in pint, quart, and gallon cans, and 5 and 55-gal drums. **Industrial Lubricants Div., Lehigh Chemical Co.**, Chestertown, Md.

Circle 740 on Page 19

Drum Counter

is subminiature, four-digit unit

Model 3523 is a four-digit, low-cost, reversible counter. Diameter of drums is 0.46 in. with ⅛-in. high characters. Unit has Geneva-movement pinions and gears molded of impact-resistant thermoplastic. Furnished with a mounting bracket for miniaturization, counter has unit lugs which can be clipped off and two screws used in base for mounting. **Haydon Instrument Co.**, 165 W. Liberty St., Waterbury 20, Conn.



Circle 741 on Page 19

Data Elements

are now produced entirely of metal

Inductosyn data elements, consisting of scales, sliders, rotors, and stators, are used for machine tool, missile, navigation, and fire-control systems for both linear and angular positioning. Formerly made of glass, they are now produced entirely of metal. Units provide simple, reliable means for direct measurement and control of mechanical movements to accuracies of 40 mu in. in linear and 1 sec of arc in angle. Conductor patterns of the all-metal scales and sliders are of metallic copper, 0.002 in. thick, secured to a thick metal base by an insulating bonding layer, 0.0025 in. thick. Bases are iron, steel, stainless steel, aluminum, magnesium, and titanium to match metal of machine to which they are mounted. Rotary units are supplied in all metals with improved transformation ratio when iron. **Farrand Controls Inc.**, 4401 Bronx Blvd., New York 70, N. Y. D

Circle 742 on Page 19

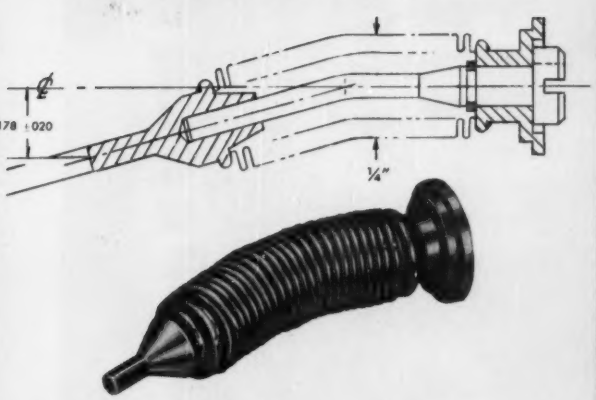
Control Knobs

have sloping pointers to eliminate parallax

Two bar-knob styles which virtually eliminate parallax through use of sloping pointers have been added to a line of control knobs. Series 70 knobs are furnished in black or

MINIATURE BELLOWS

SAVE SPACE AND WEIGHT WITH RUGGED, MINIATURE ROBERTSHAW METALLIC BELLOWS

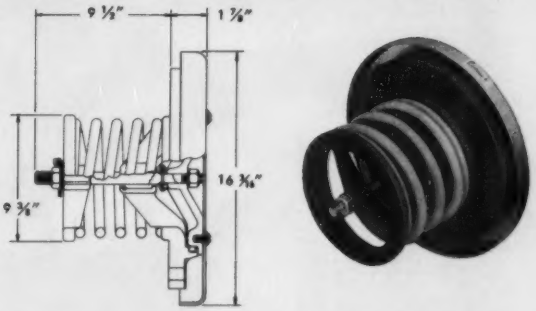


Seamless metallic bellows only ¼" and ⅜" O.D. permit further miniaturization in aircraft, missiles, instruments and other equipment. Available in a wide range of bellows metals to provide the desired strength and performance characteristics. Sensitive to temperature and pressure changes. Custom-engineered . . . but available in any quantity you need. Proved in dozens of miniaturized assemblies. WRITE FOR BULLETIN N-102

Circle 544 on Page 19

PRESSURE RELIEF VALVE

VENTS PRESSURE BUILD-UP IN TRANSFORMERS, TANKS . . . RESEALS AUTOMATICALLY WITH NO RESETTING!



Now you can forget breakaway seals that have to be replaced each time dangerous high pressure build-ups are relieved. Robertshaw Pressure Relief Valve operates instantaneously. No moisture or contaminants can enter vessel during blow-off or automatic resealing and resetting. No periodic inspections necessary.

WRITE FOR ENGINEERING DATA SHEET N-902 *Circle 545 on Page 19*

Robertshaw

BRIDGEPORT
THERMOSTAT DIVISION
Milford, Conn.

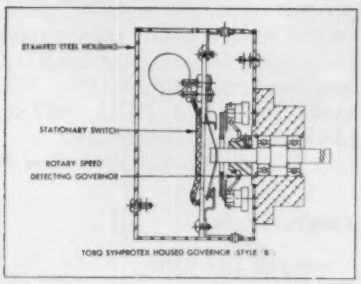
. . . FAST, UNIFORM PROCESSING – 1965 . . .
CAMBRIDGE METAL-MESH BELTS are the answer to the big problems you'll face in the competitive 60's—tighter operating costs, higher production and consistent quality.
Continuous movement of foods, metal parts, ceramics or chemicals on Cambridge Belts through processing operations speeds production and eliminates costly manual handling. Open mesh construction allows heat, cold or liquids to flow through the belt and around the product for thorough, uniform treatment. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs.
Belts can be made heatproof, coldproof or acidproof — in any mesh, weave, metal or alloy — with any side or surface attachments.
Have your Engineering Department call the Cambridge Field Engineer in your area. He'll be glad to discuss any aspect of Cambridge Belts — from manufacture to installation and service. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.
Cambridge
CONVEYOR BELTS
The Cambridge Wire Cloth Co.
Department N • Cambridge 2, Md.
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

gray, with or without dial skirts, and in either mirror or nonreflective matte finish. Knobs comply fully with military specifications. **Commercial Apparatus & Systems Div., Raytheon Co.**, Waltham 54, Mass.

Circle 743 on Page 19

Speed-Detecting Governors

are now housed in stamped-steel box



Synprotex speed-detecting switches are furnished in new box housing, designated Style B. Stamped-steel housing accepts up to two different speed-detecting units, each of which can detect a high and low limit. Speeds from 500 to 4000 rpm can be detected. Box, complete with wiring knockouts and flange for external mounting, is 2¾ x 4½ x 3 in. in size, with shaft length and diameter to order. Switches used detect predetermined speeds within 1 per cent. They are actuated by speed alone, independent of voltage, load, or other environmental conditions. **Torq Engineered Products Inc.**, 32 W. Monroe St., Bedford, Ohio.

Circle 744 on Page 19

Silicon Glass Diodes

for computer and general applications

Glass-package, ¼-w silicon zener diodes have many applications in oscillators, dc-coupled amplifiers, switching circuits, multivibrators, level shifters, clamps, subtractors, and references. Diodes, in an axial-lead package, feature a type-number marking on each unit, rather than color banding system used on similar devices. They are particularly valuable as replacements for neon lamps in computer circuits where photon emis-

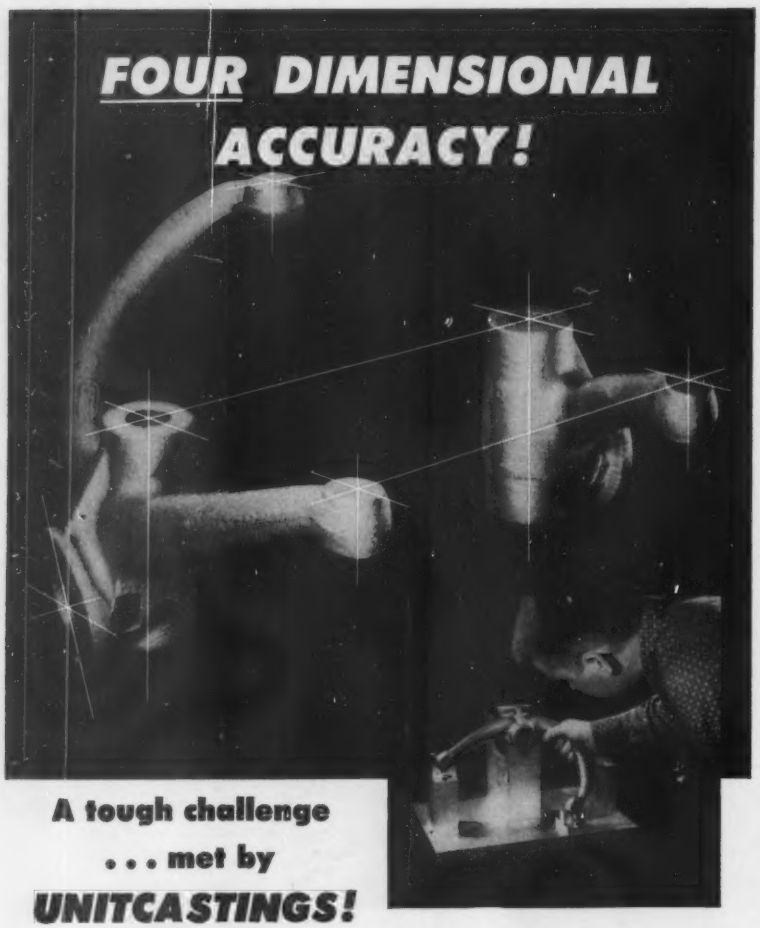
New Hydraulic Packing Designs..... Specification & Application Data....

Here is complete information on the finest available line of hydraulic packings... an extremely wide variety of types and constructions, each correctly compounded to particular service requirements and laboratory controlled to insure uniform quality. Available now from "John Crane", this complete line is the answer to practically every hydraulic packing requirement.

Request Catalog 90. You can't afford to be without this detailed engineering guide.

Crane Packing Co., 6425 Oakton Street, Morton Grove, Illinois *(Chicago Suburb). In Canada: Crane Packing Company, Ltd., Hamilton, Ont.*

Circle 547 on Page 19



A tough challenge
. . . met by
UNITCASTINGS!

Four-way specifications for this pair of steering arms combined tolerances difficult to hold in sand casting. Structural contour, surface limitations and internal consistency are accepted with regularity at Unitcast. However, a fourth requirement, *relationship of extremities* in such an unusual casting design is a tough problem to solve *economically!*

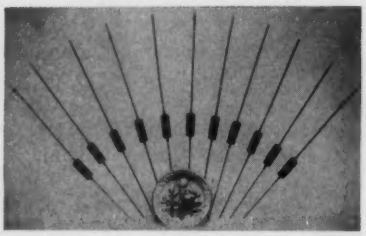
With a reasonable *finished* cost as an objective, Unitcast's quality control specialists recommended an unorthodox molding method. Special pattern equipment was built to control distortion in the spider-like arms . . . metal flow was redirected along with other unusual procedures. Finally, inspection jigs assured delivered accuracy.

Unitcastings *more* than meet customer's requirements and *cost remained competitive!* Unitcast can offer a similar service for your problems . . . call today for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNICAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS



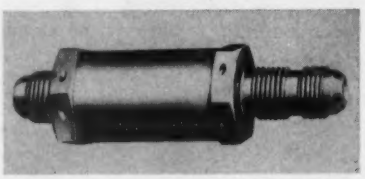
sion is not required. Entire series, 1/4M6.8Z through 1/4M200Z, offers 43 separate voltages from 6.8 through 200, in tolerances of 20, 10, and 5 per cent. Excellent electrical stability and mechanical ruggedness combine to provide maximum reliability. **Semiconductor Products Div., Motorola Inc.**, Dept. NGD, 5005 E. McDowell Rd., Phoenix, Ariz.

Circle 745 on Page 19

Control Valve

controls flow into hydraulic motor

Lightweight valve stops hydraulic motor run-away, prevents damage to equipment, and assures safe working conditions. Operating pressure for the 5-oz unit is 3000 psi. Normal flow is 2.2 gpm with maximum allowable flow of 3.5 gpm and limited flow of 0.5 gpm. Pressure drop across valve is 20 psi max for flow of 2.2 gpm. Speed limiter automatically limits flow when it reaches maximum setting. After inlet pressure is reduced to 15 psi,



valve automatically resets and permits normal flow. Constructed of stainless steel, with bulkhead fitting on outlet port, unit handles usual hydraulic fluids and oronite. **Fluid Regulators Corp.**, 313 Gillette St., Painesville, Ohio.

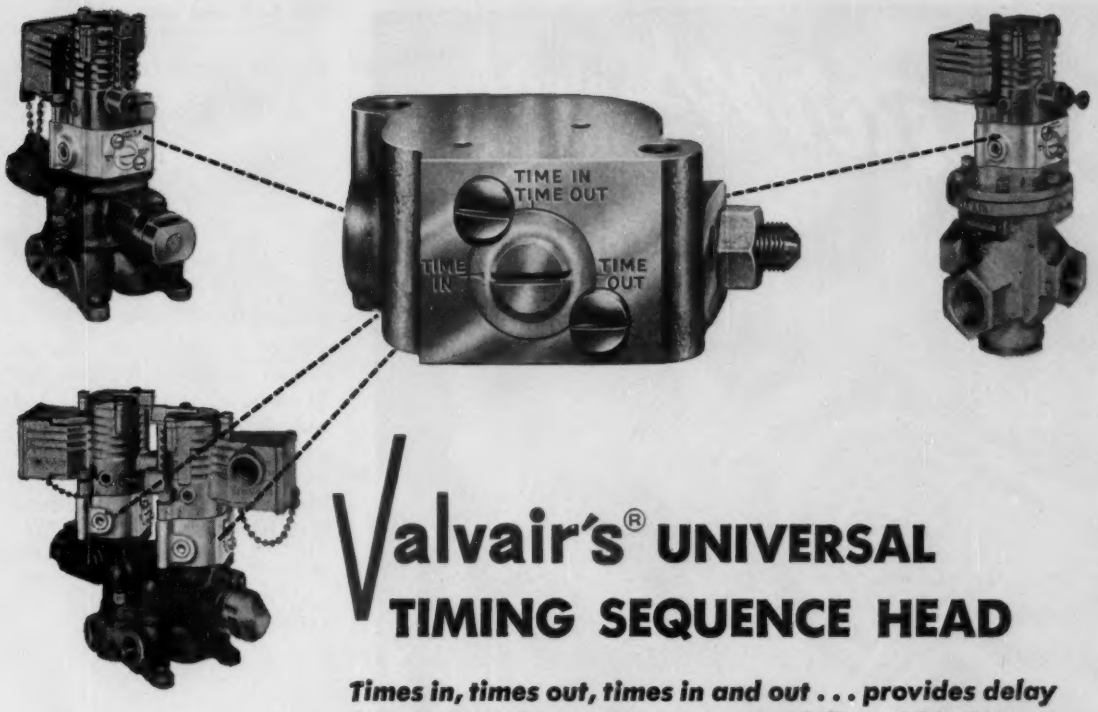
Circle 746 on Page 19

Coupling and Clutch

is available in a wide variety of bores

Universal in-line coupling and slip clutch, designated T14, is available in a wide variety of bores in both

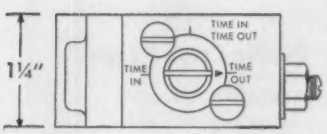
Circle 548 on Page 19



Valvair's® UNIVERSAL TIMING SEQUENCE HEAD

Times in, times out, times in and out . . . provides delay from 0 up to 30 seconds . . . repeatability within 2% . . . changes function without disassembly . . . for use with any Valvair Speed King or Inline Valve

For accurate control, to simplify circuits, to eliminate timers and relays, to lower control component installation and maintenance costs, use Valvair's universal timing sequence head. This unit is supplied in two types; one for direct mounting between the pilot and valve body; one for direct mounting on the valve body, with remote pilot control.



Function can be changed in seconds, *without disassembly* and with line pressure on the valve. Just loosen the lock screws slightly, turn the indicating barrel to the desired function mark, then tighten the lock screws.

A port is provided for installation of accessory reservoir capacity . . . delay can be extended up to several minutes. And, the Valvair name on this unit is your assurance of sound design, quality construction, micro-accurate performance and multi-million cycle dependability!

Find out how Valvair's sequence head can provide the results you want, at a cost saving you'll like, on the new equipment you're designing or on existing machines you're up-grading. Yes, this sequence head can be used on your present SPEED KING and INLINE valves, too. Ask your Valvair or Bellows Field Engineer for recommendations . . . they're located in over 125 major industrial cities.

For more information, write for Bulletin E-1A. Address Dept. MD260. Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio.

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

8079

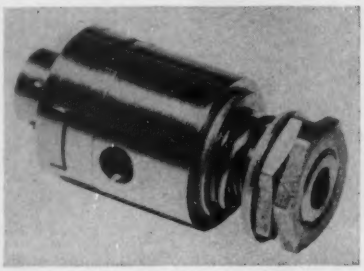
Circle 549 on Page 19

. . . designed for tomorrow's requirements rather than yesterday's applications!

Whatever the requirements — for missiles or machines — for computers or conveyors — for rockets or rolling mills — there's a Stearns Clutch, Brake, or Clutch-Brake designed, tested and in production for that application . . . right now! Stearns *Standard Line* covers the most complete range available anywhere . . . from *complete lines* of tiny-but-rugged Miniatures — up to the heavy-duty, hi-torque units used with ball mills and steel mill equipment. *"Designed for Tomorrow's Requirements"* signifies: 1. Prompt availability of fully assembled, tested units. 2. Higher torques in less space, with less weight — while maintaining up to 3 times the friction lining area of competitive units. These factors alone insure delivery *WHEN* you want it — at lower shipping costs . . . install them faster, easier . . . units that will operate more quietly, efficiently, smoothly — with less maintenance, l-o-n-g-e-r, under *ALL* conditions. Proof . . . over 40 years of steady growth in just this one field — Clutches, Brakes.

For solutions to YOUR brake and clutch problems, call the Stearns representative in your vicinity. Or write, stating your specific requirements, directly to . . .

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN



split or pin-type hubs. Spring-slip torques are adjustable from 0.05 to 50 oz-in. Shaft-to-shaft misalignment is up to 0.01 in., and angular misalignment up to 1 deg. Maximum backlash is 10 min. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y.

Circle 747 on Page 19

Teflon Tape

for wire wrapping

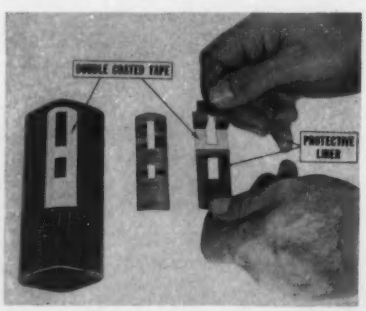
Teflon skived tape with controlled low-shrinkage shows no more than 2 per cent change in any dimension when heated free at 730 F for 15 min. Tape is available for wire manufacturing requiring insulating materials which are capable of withstanding prolonged exposure to high temperatures without cracking or splitting. It is available in thicknesses from 1 mil up and widths from ¼ to 12 in. **Dixon Corp.**, Briston, R. I.

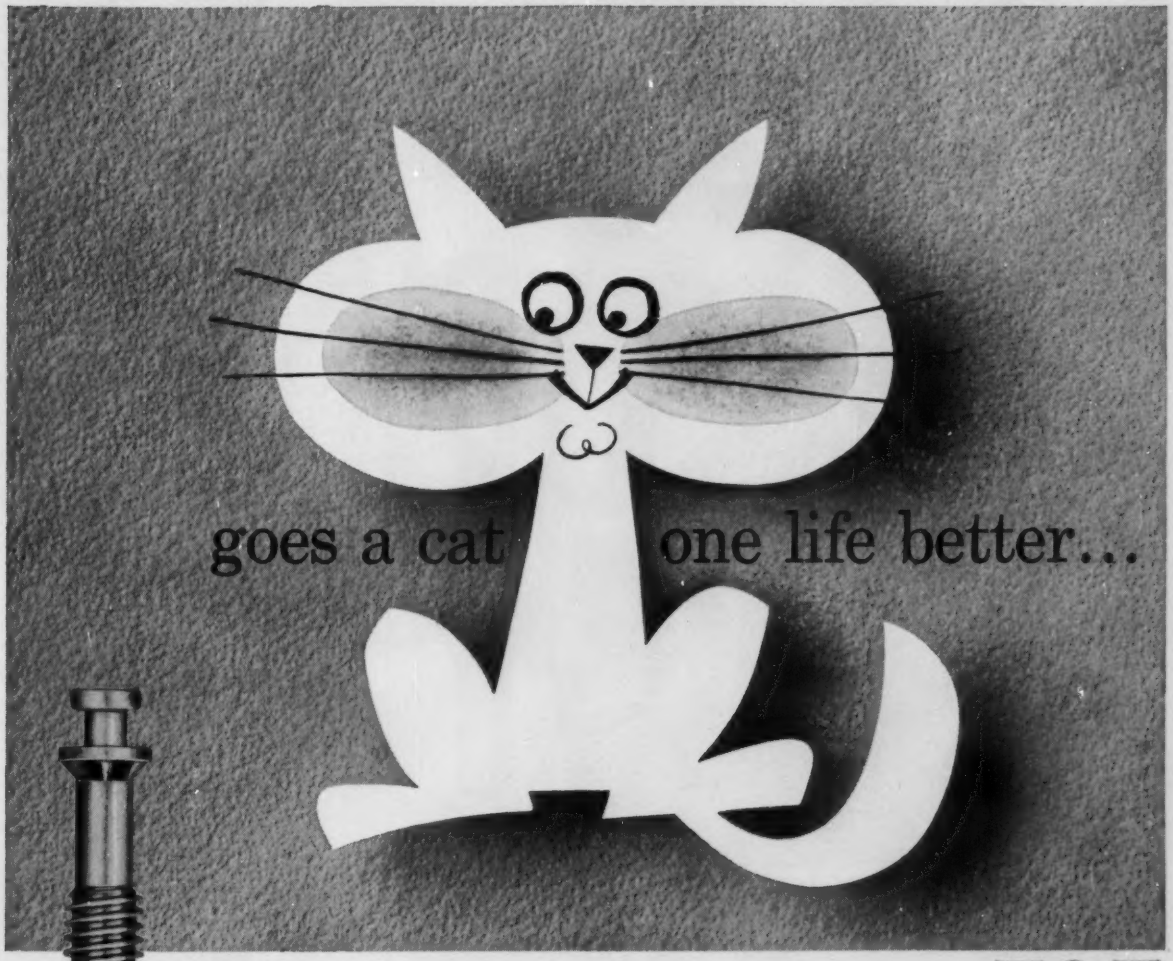
Circle 748 on Page 19

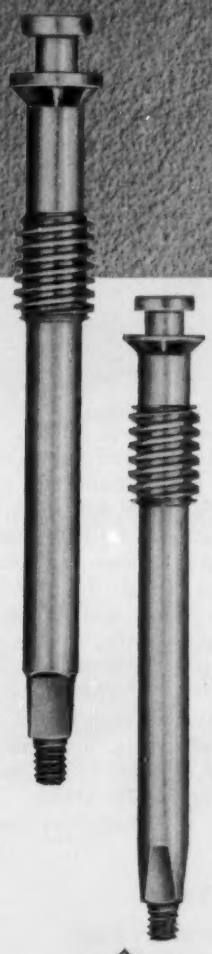
Double-Coated Tape

provides low-cost bonding method

Positive, permanent bonding of plastics, wood, metal, leather, and fabric surfaces in manufacturing and assembly operations is done faster, more economically with pre-cut double-coated tape. Products are manufactured from self-sticking



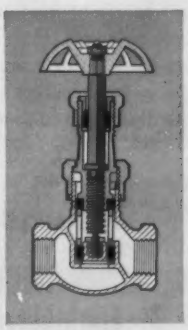




Bridgeport Duronze 707

A tenfold increase in service life... that's the outstanding contribution made by Bridgeport's Duronze 707 to gate valves manufactured by Ohio Injector Company, Wadsworth, Ohio. The big difference is in the valve stems. Duronze 707 not only provides exceptional strength in the stems, but also eliminates risk of seizing or galling. Thread wear is kept to a minimum. In addition, this corrosion-resistant alloy offers an important manufacturing advantage in good machinability.

The toughest valve stems the industry has ever known were evolved through close cooperation between Bridgeport and Ohio Injector metallurgists. This type of cooperation is open to all manufacturers. It means that a *standard* alloy can often be chosen to provide the most effective and economical solution to product or production problems.



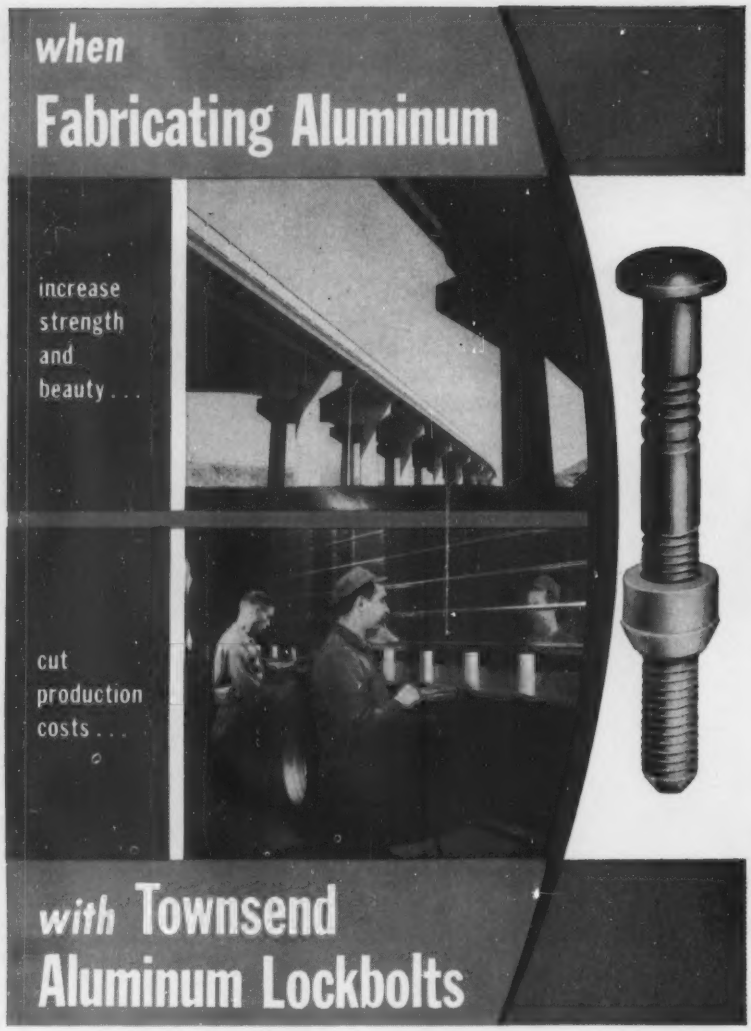
Bridgeport Technical Service will gladly advise you on any problems involving metals and their application. Just call your nearest Bridgeport Sales Office—or write directly to Bridgeport Brass Company, Bridgeport 2, Conn., Dept. 4302.

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut

Specialists in Metals from Aluminum to Zirconium

Circle 551 on Page 19



Appearance is improved, since the aluminum lockbolts* match the material being fastened. Joints are neat—there is no roughness or weld-splatter, no tool marks, no rust streaks after exposure to weather.

Lockbolts will not alter the mechanical values of the material being fastened, and their high tensile pre-load values are uniform. These two factors make design calculations simpler and more accurate.

Townsend aluminum lockbolts can lower your production costs, because operators with no special skill or training can make strong, uniform joints at high production rates. The setting guns are designed to eliminate the possibility of human error.

If you are fastening aluminum, investigate advantages of Townsend lockbolts. Write for Bulletin TL-101. Townsend Company, Engineered Fasteners Division, P. O. Box 71-E, Ellwood City, Pa.

*Licensed under Huck patents RE22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

Townsend Company

Engineered Fasteners Division

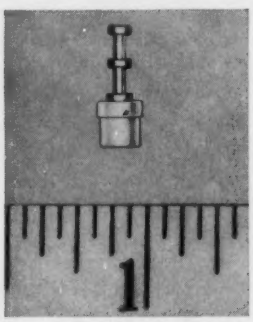
ELLWOOD CITY · PENNSYLVANIA

tapes, coated with pressure-sensitive adhesive on both sides. Tape is precision-cut to meet product requirements, and furnished mounted on dispenser cards. Products can be substituted in practically any application where liquid or paste adhesives are used, and will replace many types of metal fastening devices in assembly operations. A variety of double-coated tapes is available, many with special physical properties, to meet application requirements. **W. H. Brady Co.**, Dept. DC, 727 W. Glendale Ave., Milwaukee 9, Wis.

Circle 749 on Page 19

Press-Fit Terminal

is double-turret, Teflon unit



Terminal No. 2610 press fits into holes 0.136 in. in diam, ±0.002 in., in panels from 1/32 to 1/8 in. thick. Double-turret Teflon unit is suitable for use wherever conditions of extreme humidity and low capacity to ground are encountered. Two over-all lengths are available: No. 2610-6, 0.325 in. long with greatest spacing between top and middle turrets, and No. 2610-7, 0.365 in. long with turrets spaced approximately equidistantly. Terminals are brass per QQ-B-626a. Finish is either 0.0003-in. silver plate plus water-dip lacquer or 0.0003-in. tin-lead solder plate. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass.

Circle 750 on Page 19

4000-psi Valve

for temperatures from −65 to +275 F

No. A-70198 valve combines high-pressure hydraulic relief, pressure

Circle 552 on Page 19

Circle 553 on Page 19→

Barden Precision SFRI-5 miniature bearings as used in a computer gear train.

Specify **BARDEN** *Precision miniature ball bearings*

Precision-built computer gear trains must have uniformly low torque and minimum backlash; mounting surfaces for the bearings should be simple to manufacture.

Barden Precision miniature-size bearings have the required low torque. Their low eccentricity and closely controlled radial play assure minimum backlash. Precision flanges provide accurate positioning surfaces and permit through-boring, eliminating the need for housing shoulders.

Barden Precision miniature bearings are built to the same high standards of consistent quality as Barden's larger instrument sizes.

Barden Precision means not only dimensional accuracy but performance to match the demands of the application.

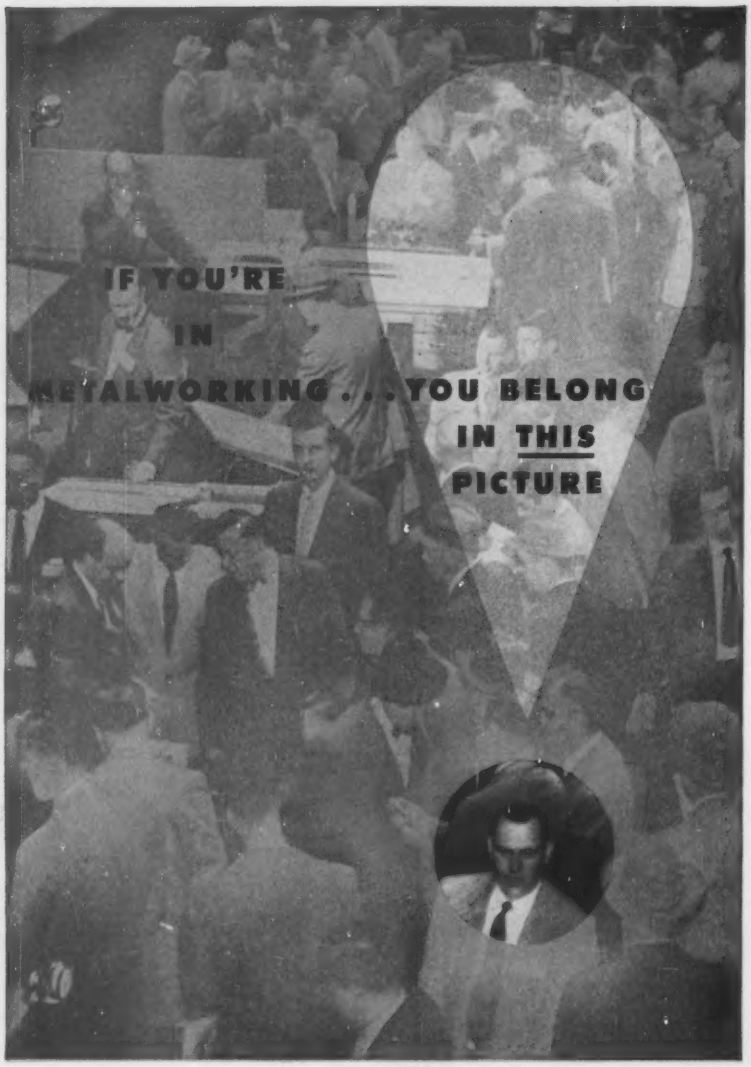
Your product needs *Barden Precision* if it has critical requirements for accuracy, torque, vibration, temperature, or high speed. For less difficult applications, the *predictable* performance of *Barden Precision* bearings can cut your rejection rates and teardown costs.

Write today for your copy of Catalog Supplement M1 which gives dimensions, performance and engineering data on *Barden Precision* ball bearings 5/8" O.D. and smaller.

THE BARDEN CORPORATION

208 Park Ave., Danbury, Connecticut • Western office: 3850 Wilshire Blvd., Los Angeles 5, California

SPECIFY BARDEN PRECISION BALL BEARINGS FOR: INSTRUMENTS • AIRCRAFT ACCESSORIES • COMPUTERS AND RECORDERS • MACHINE TOOL AND TEXTILE SPINDLES • OTHER PRECISION APPLICATIONS



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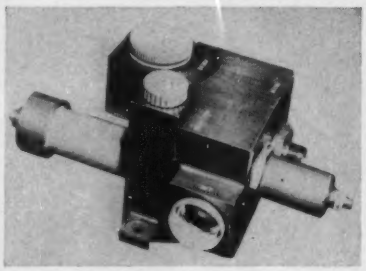
Circle 554 on Page 19



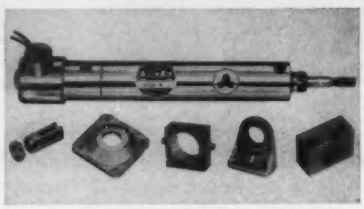
reducer, and check valve. It operates at pressures to 4000 psi at temperatures from −65 to +275 F. Designed for hydraulic fluid per Specification MIL-0-5606, it can be adapted to use other hydraulic fluids. **Vinson Engineering & Sales Corp.**, 8044 Woodley Ave., Van Nuys, Calif.

Circle 751 on Page 19

Air Cylinders

are single-acting units with three-way solenoid valve

Two new models of valve-in-head cylinders are single-acting units featuring a three-way solenoid valve built into rear head. Model AVSA is designed for gravity or air return, and Model AVSR features an internal spring to return the rod. All barrels and heads are brass; rods are ground and polished stainless steel. Both models are available in all popular voltages. Choice



of four mounts is offered, as well as a rod clevis. **Allenair Corp.**, 255 E. Second St., Mineola, N. Y.

Circle 752 on Page 19

Insulating Material

permits high transformer loadability

HT 50 insulating material permits high thermal overloads in oil-filled transformers with no sacrifice of insulation life. It gives same life expectancy at 30-C higher operating temperatures than standard transformer insulation papers and boards

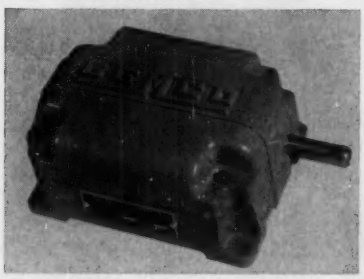
give at 105 C. Material remains inert in both standard and inhibited transformer oils. It is comparable with standard insulating media in oil absorption, formability, and other physical properties. Material is available for field evaluation in sheets from 0.031 to 0.25 in. thick. **Spaulding Fibre Company Inc.**, 310 Wheeler St., Tonawanda, N. Y.

Circle 753 on Page 19

Rotary Limit Switches

are explosionproof

Rotary limit switches with gear ratios from 5:1 to 1750:1 are now housed in lightweight, cast-aluminum NEMA-7 enclosures. Positive, independent cam settings allow adjustments of one cam without upsetting position of other. Switch is



rated at 125, 250, and 460 v, 15 amp ac, 125 v, ½ amp dc, 250 v, ¼ amp dc. Self-lubricating, powdered - metal - impregnated bearings give lifetime lubrication. **Gemco Electric Co.**, 25685 W. Eight Mile Rd., Detroit 40, Mich.

Circle 754 on Page 19

Copper-Clad Laminate

is flame retardant

Copper-clad, hot-punch, paper-base phenolic laminate is called either Fireban 321-R or Fireban 321-E, depending on whether copper foil is rolled or electrolytically deposited. Material possesses excellent punching and electrical characteristics, including high insulation resistance and surface resistivity in base stock. Flame-retardant material is offered in sheets of approximately 36 x 48 in. in thicknesses from 0.02 to 0.25 in. Base stock is translucent and can be cold-punched to 1/16 in. thickness. Maroon in color, laminate is furnished with a semigloss finish, number 4 plate. Copper foil,

Most Important Event in METALWORKING

1960 ASTE TOOL SHOW and CONFERENCE

530 exhibitors will be on hand to show and demonstrate more than 6,000 products . . . machine tools and attachments, precision control and inspection equipment, automation devices, cutting tools, dies, jigs and fixtures . . . everything, in fact, that's *new* in tools and tooling. It's your best opportunity to see, study, compare . . . under one roof, at one time . . . the most modern, scientific methods, processes and tools in metalworking.

Equally important, the Tool Engineering Conference, with its 36 technical sessions, 70 outstanding papers, offers you an opportunity to learn about and discuss the latest technical advances and developments in the science of tool engineering.

There'll be plant tours, too . . . a chance to see and study, in actual operation, product and process methods in the world's major center of high-volume production.

All of these scientific and educational attractions, and more, will bring more than 35,000 metalworking management, engineering and production men to the 1960 ASTE TOOL SHOW. Make sure you're one of them! Write or wire immediately for your rapid registration forms.

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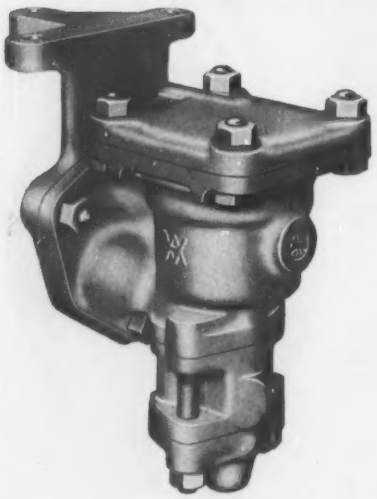
Typical Control Functions solved by AIR CIRCUITRY



● The H-5 RELAYAIR Valve, one of many Westinghouse Air Circuitry Components, is a pilot operated, directional control valve. It may be normally open or normally closed, depending upon port connections.

Various spring settings provide operating pressures from 3 to 150 psi. An easily removable pipe bracket permits removal of valve without disturbing pipe connections.

Envelope size: 7¼" x 7⅛" x 4⅛"
Maximum supply pressure 200 psi.

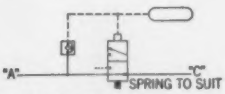
Typical Applications—In addition to the illustrated functions, this highly versatile valve has been and can be used in all conceivable types of air circuits. Some of these are as follows: cycling operations, safety interlocks, low pressure alarm signals, emergency cut-off of power, emergency brake applications, remote control station relays, sequence control timing, and many many others.

If you have a control problem, let us know about it. It can probably be solved with Air Circuitry. For more information, ask for Catalog A5-81.01.

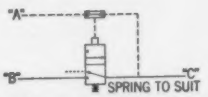
What is air circuitry?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise Air Circuitry is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

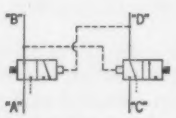
1. RELAY—To increase flow or pressure in an air circuit. An air signal directed to line "A" overcomes a spring opposed diaphragm to connect line "B" to line "C." Various spring values determine operating pressure.



2. TIME DELAY—To provide automatic power unloading. Air signal pressure in line "A" flows through the device to line "C" to perform specified operation. A check valve with choke and a volume provides a time delay by requiring a predetermined pressure be built up before line "C" is vented to atmosphere.



3. LOCK-UP—To provide a hold-in feature. Air signal in line "A" connects line "B" to line "C." Air from line "C," through a shuttle valve, holds this connection when signal air is vented.



4. CRISSCROSS INTERLOCK — To prevent energizing one line before another is vented. With lines "A" and "B" energized with air pressure, line "D" is vented to atmosphere. Line "D" cannot be energized until line "B" is vented. The converse is true when lines "C" and "D" are energized.

5. SEQUENCE INTERLOCK—To insure one function is performed before another is initiated. Line "A" must be energized to a predetermined pressure before line "B" can pass air to the next function.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

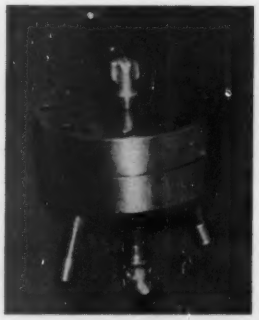
WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

furnished on one or both sides, has minimum purity of 99.5 per cent. Rolled foil is available in thicknesses of 0.0014, 0.0028, and 0.0042 in. Electrolytically deposited foil has thicknesses of 0.0014 or 0.0028 in. **Taylor Fibre Co.**, Norristown, Pa.

Circle 755 on Page 19

Manifold Valve

is differential-pressure type unit



Having only one moving part, differential-pressure manifold valve is actuated on control side by air, gas, or other fluids. Working side handles same or other gases, fluids, or slurries. It is available in a variety of materials including aluminum, brass, nylon, Teflon, and stainless steel. Port sizes range from ⅛ to ½ in. NPT on both control and working sides. Fast response, quiet operation, and economical installation are additional features. **Frankel Engineering Laboratories Inc.**, 207 S. Fifth St., Reading, Pa.

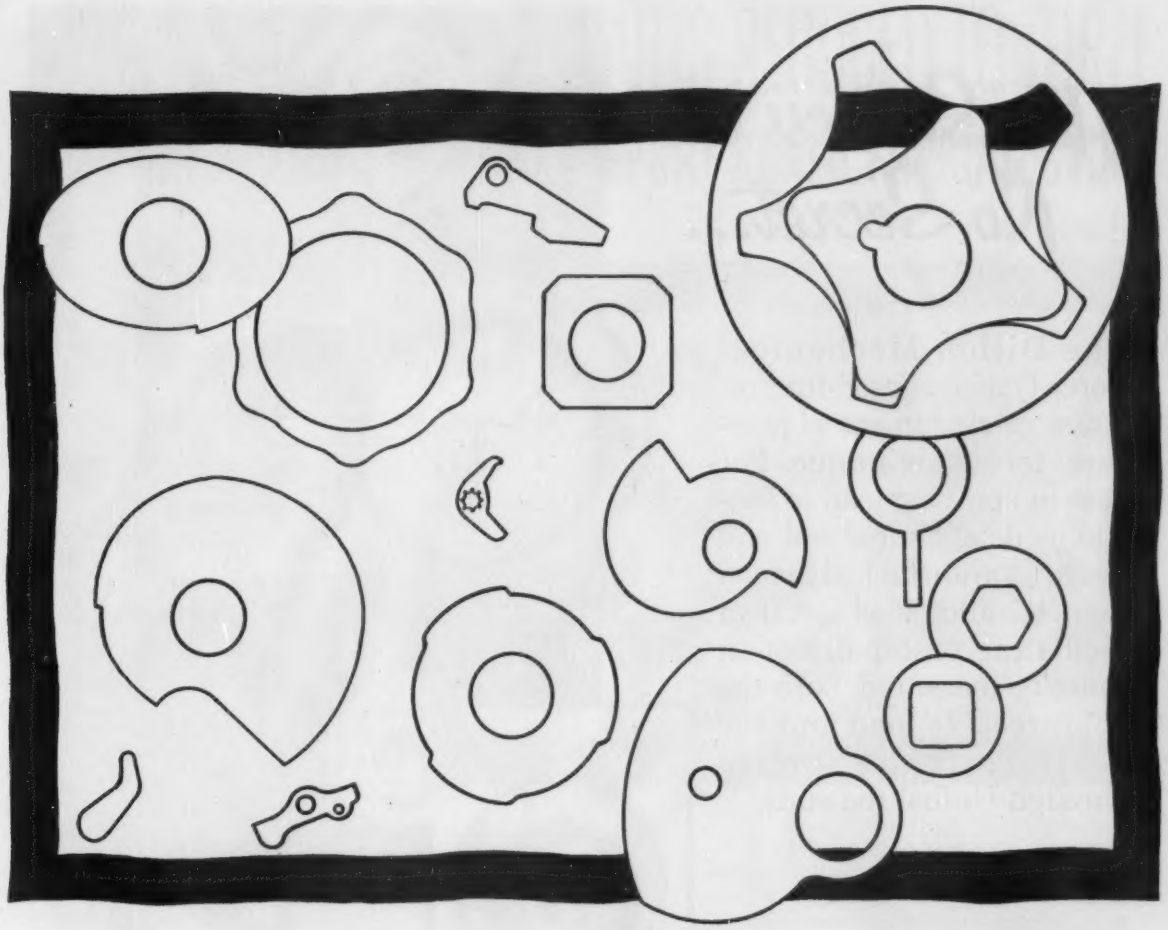
Circle 756 on Page 19

Positive-Drive Belt

for speeds under 100 fpm to more than 10,000 fpm

Combining the advantages of the chain and gear with advantages of belt, positive-drive belt is built on a toothgrip principle. Molded teeth of the belt make positive engagement with mating axial grooves on the pulleys. Drive provides unusually versatile applications on drives to 600 hp and from speeds under 100 to more than 10,000 fpm. Advantages include elimination of slippage, negligible friction, no need for lubrication, and a wide range of constant speed. Positive-drive belt drives are light

Circle 555 on Page 19



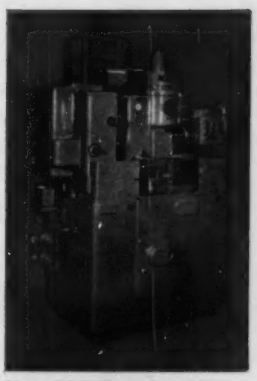
NOT ALL GEAR SHAPERS CUT GEARS

. . . a lot of them are in production, cutting parts having non-involute shapes of various kinds. Many designers take full advantage of the versatility of the Gear Shaper by designing odd-shaped parts that can be easily and economically generated by merely using special Fellows cutters and fixtures on their standard Fellows machines.

The almost unlimited variety of work includes square and elliptical shapes, cams, pawls, pump rotors, etc., both internal and external.

Remember this *plus* value which helps guarantee a full, profitable work load on your Fellows generating equipment.

"The Art of Generating with a Reciprocating Tool", a fact-packed 48-page catalog, gives details on this versatile production technique. May we send you a free copy?



No. 4GS Fellows Gear Shaper

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont, U.S.A.
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1048 North Woodward Ave., Royal Oak, Mich.
150 West Pleasant Ave., Maywood, N.J.
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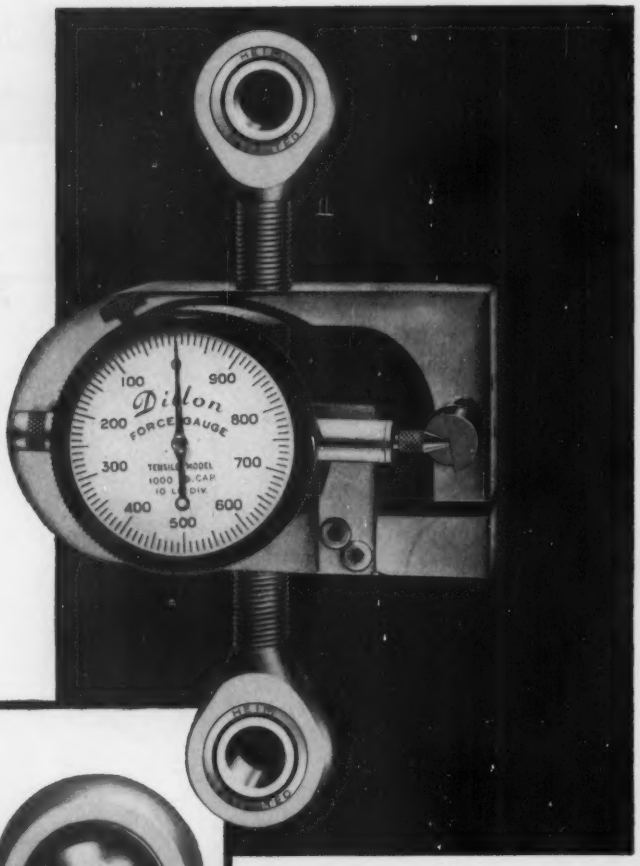
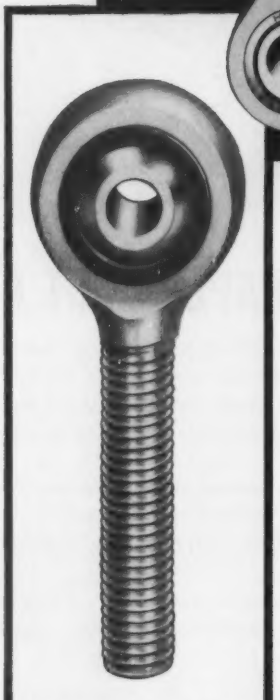
THE PRECISION LINE

Fellows *Gear Production Equipment*

This Success is No Secret...

The Dillon Mechanical Force Gauge is used for precision measurement of pressure, tensile or torque. For ease in applying load to tensile models, Unibal rod end bearings are attached to each leg of the alloy steel bar. If an oscillating, push-pull motion must be measured, both the compressive load and the tensile load are applied through Unibal rod ends.





Heim Unibal Male Rod End

In this case, an instrument calibrated 180 degrees in compression (reading clockwise), and 180 degrees in tensile (reading counterclockwise) is required.

Here is a true success story of a device, built with watchmaker's precision, which is designed to check all such loads, even in limited space.

It is no secret that the

HEIM *Unibal*® SPHERICAL BEARING ROD END

contributes to the successful operation of the Dillon Force Gauge. Two Unibal male-threaded rod ends are attached to the pressure bar. Calibration in both tensile and compression is conducted against a pin placed through the Unibal, or eye, of the rod end.

Heim Unibal corrects misalignment in every direction, reduces friction, carries maximum loads, saves time and money in assembly.

All Heim bearings are available through the leading bearing distributors in the U. S. and Canada. Send for complete catalog with distributors' names and locations.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

in weight, with a high horsepower-to-weight ratio, require minimum space because of compact design, and maintain a low noise level. They are free from heat build-up and have high mechanical efficiency. Belts have steel-cable tension members, providing high tensile strength, long flex life, and high resistance to elongation. Durable neoprene backing which encases tension member protects cables from grime, oil, and moisture, and from frictional wear. Positive-drive belts are adaptable to almost any kind of power-transmission drive. **Durkee-Atwood Co.**, 215 N. E. 7th St., Minneapolis 13, Minn.

Circle 757 on Page 19

Heavy-Duty Couplings

in shaft sizes to 6 in.

Torque-disconnecting couplings are readily adjusted within a wide range of torque values. They are extremely accurate, disconnecting at a preset torque value, practically independent of friction, dryness, or oiliness of surfaces. Couplings are readily reset after disconnecting. Shaft sizes range from small units to 6 in. **Odin Corp.**, Castleton, Ind.

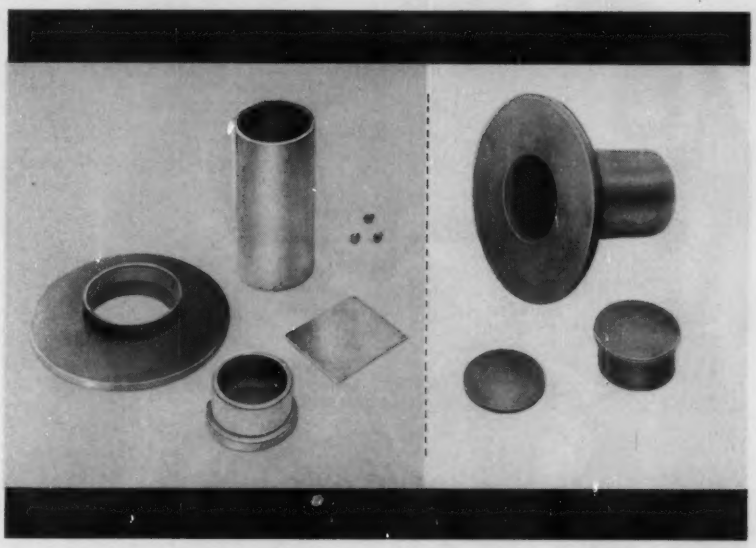
Circle 758 on Page 19

In-Line Valve

has high flow coefficient

Compact ½-in., in-line valve has a flow coefficient of 7.5 and is rated for 300 psi maximum pressure at 180 F. Valve is only 2¾ in. in diam and 3½ in. long, including hexagonal, screwed connections. It has a minimum number of parts, and plug can be reversed in the field without extra parts. Valve is ported on both sides of operating piston and can be assembled for spring-to-open or spring-to-close operation. Springs of different rates

SEVEN PARTS REDUCED TO THREE
—A BRIDGEPORT CORED FORGING STORY

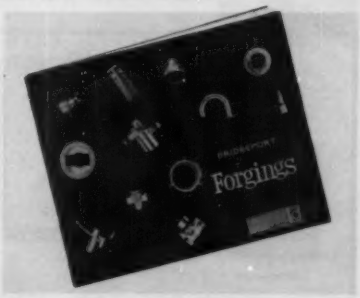


The conventional 7-part stanchion socket shown on the left requires a cast base and tubing, cast cap, brass web and three rivets. Manufacturing it involves some 20 operations including machining, cutting, soldering, drilling, riveting, and final polishing and plating.

In comparison, the cored forging stanchion socket, on the right, developed by Bridgeport's Cored Forging Division requires only 3 parts and a total of 5 assembly operations. The socket and cap are forged to perfect dimensions...only polishing and plating are needed. For the web, a piece of scrap trimmed from the forging is utilized. Just the right size, it requires only a press fit.

Result is a big 20% savings in processing, assembly and labor costs, plus additional benefits in improved appearance and performance. Moreover, the cored forging stanchion socket is stronger and lighter in weight, giving an extra bonus in reduced shipping costs.

Bridgeport's forging processes, both solid and cored, offer similar outstanding advantages for *your* component or part. A skilled Engineering Staff is ready to serve you. They can show you the way to better products at less cost.



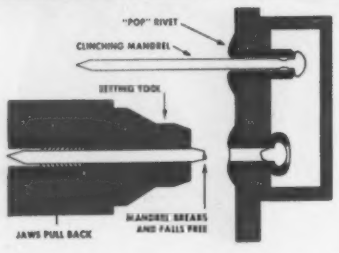
Write to Dept. 8901 for your copy of a detailed 12-page brochure, "Bridgeport Forgings," and a free analysis of your forging problems.

CORED FORGING DIVISION
BRIDGEPORT BRASS COMPANY
1000 Connecticut Ave., So. Norwalk, Conn.
Specialists in Metals from Aluminum to Zirconium

Circle 558 on Page 19

"POP"®
RIVETS
SAVE THE SURFACE

Assemble finely finished wood chair panels, enameled or painted metal sheets. "POP" Rivets save the surface. Setting tools can't slip. Burrs on fastener head and countersinking are eliminated.



HOW THEY WORK — "POP" Rivets are assembled on a precision high-tensile mandrel. Mandrel head is drawn into the reverse side of rivet with a setting tool. Mandrel head breaks off under tension clinching the rivet. Work is squeezed by compression — controlled radial expansion. Setting tools from $18 to $300.

"POP" Rivets set by compression without the turning action which tears the surface finish allowing corrosion to start. Fasten sheets as thin as .020 dead soft aluminum or 24 gauge steel without distortion. Use thinner materials without creating a fastener problem.

"POP" Rivets install and set from same side. Get this design advantage for your product. Set up to 1,000 an hour with unskilled help. 50% savings in installed fastener costs suggest your immediate investigation.

"POP" RIVET DIVISION
UNITED SHOE MACHINERY CORPORATION
RIVER ROAD, SHELTON, CONN.
REgent 5-3391

UNITED "POP" RIVETS

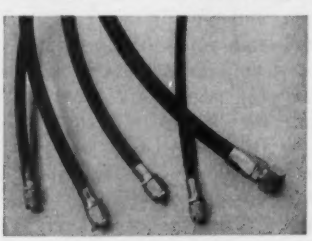
are available to suit operating conditions. Valve can also be operated without spring as a double-acting piston for hydraulic actuation by any well-known displacement method. It is available in any bar-stock material, has a bronze sleeve and bridge, stainless-steel plug, and neoprene O-rings. George W. Dahl Co. Inc., 86 Tupelo St., Bristol, R. I.

Circle 759 on Page 19

Nylon Pressure Hose

for operating pressures to 1250 or 2000 psi

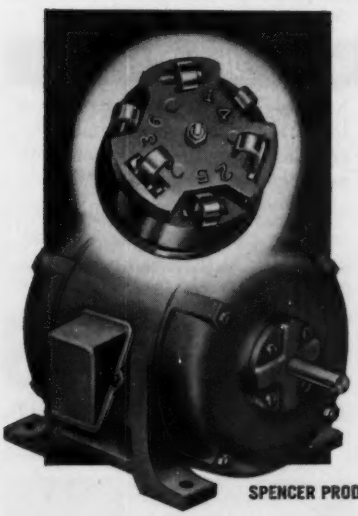
Nylaflow pressure hose has a specially formulated nylon inner tube reinforced with high-tensile-strength yarn. It is one-fifth the weight and has a wall thickness less than one-half that of rubber hose with equivalent burst strength. Hose, with abrasion-resistant cover, exhibits outstanding resistance to flexing, pressure-pulses, and vibrational fatigue. Unaffected by flammable and nonflammable hydraulic fluids, hose has low Freon permeability, approximately one-tenth that of rubber hose. It has excellent resistance to caustics and almost all organic solvents, is nontoxic, noncorrosive, fungus resistant, and will not embrittle in storage. Hose retains excellent flexibility and toughness in temperatures from −65 to +200 F (constant), and intermittently to



HUNTING

for a Solution to STOP MOTOR BURNOUTS

Specify and use 3-phase motors with built-in KLIXON PROTECTORS



SPENCER PRODUCTS

RESULT . . . • *Eliminate Motor Burnouts* • *Get Maximum Motor Output* • *Reduce Costly Equipment Down Time*

No matter what the motor application . . . whether it be textile looms or turret lathes . . . ventilating fans or rolling mills . . . built-in KLIXON Protectors keep motors from burning out under all conditions that cause overheating.

Built-in by the motor manufacturer, as an inherent part, KLIXON Protectors are matched to the thermal characteristics of the motor providing a tested and proven combination to assure full protection. KLIXON Protectors safeguard motors and prevent burnouts caused by the following conditions . . . prolonged overloads, unbalanced voltage, stalling, failure to start, increased ambient temperatures, lack of ventilation, plugging,or reversing duty, and single phasing.

And remember, get the same complete protection in your single phase motors, too.

KLIXON protected motors are available from your motor supplier. The additional cost is low, the savings great. Ask your motor supplier for KLIXON protected motors.

Write for a free copy of Bulletin PR-1243. It gives the complete story.

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METALS & CONTROLS DIVISION
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SPENCER PRODUCTS: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Big space savings now possible with integral design "insert package" that replaces complete pump

Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

The reliability-proved Gerotor pump has long been recognized as a space-saving unit because of its extreme flexibility of design. That's because Gerotor pump capacity is a function of diameter, thickness, number of teeth and rpm of the two moving parts. These variables can be matched to just about any space restriction and capacity requirement. Now, you can save even more space by building three simple pump components into your mechanisms with no more trouble than providing for an anti-friction bearing. *(Fig. 1.)*

These built-in Gerotor pumps are rugged, positive-displacement, valveless units capable of handling a variety of liquids at rates up to 100 gpm at pressures to 1,000 psi. *(Fig. 2.)* They're lightweight, high in mechanical and volumetric efficiency and are balanced and quiet in operation. Total cost, including our components and your machining and assembly is far less than what you would pay for comparable complete pumps purchased outside and mounted on your mechanism.

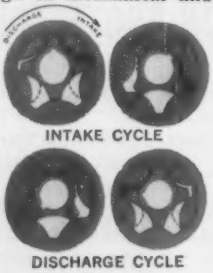


FIG. 2

Multiple pumping functions, such as lubricating, scavenging, boosting, etc., can be similarly built-in by mounting several "Gerotor insert-packages" and port plates on a single shaft.

Investigate this concept of integral pump design. Our technical assistance is on call at all times to show you how to build these low-cost packages into your equipment. Write:

W. H. NICHOLS CO.
Woerd Ave., Waltham 54, Mass.

Circle 561 on Page 19

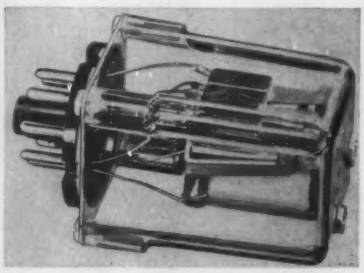
300 F. Two types are presently available, with recommended maximum operating pressures of 1250 and 2000 psi. IDs are ⅛, 3/16, ¼, 5/16, ⅜, and ½ in. **Polymer Corp. of America**, 2140 Fairmont Ave., Reading, Pa.

Circle 760 on Page 19

Plug-In Relay

incorporates new plastic cover

Operating visibility, combined with protection against tampering, dust, and iron filings, is provided by a transparent plastic cover for Class 33 plug-in mounted relays. Cover is high-impact-strength styrene which also insulates relay from electrical interference with other components. Relay can be furnished for dc operation with contact combinations to three pole, double throw. Enclosure is available with 8 or 12-pin octal-style plug which mates with Amphenol socket 77MIP-8m, -12, or equivalent. Over all dimensions, including plug, are 2-11/16 in. long by 1⅜ in. square. **Magnecraft Electric Co.**, 3350 W. Grand Ave., Chicago 51, Ill.



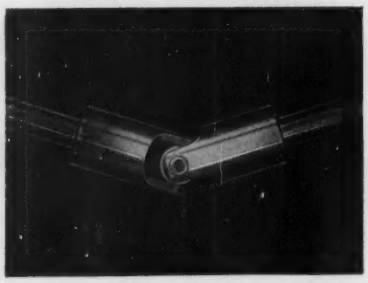
Circle 761 on Page 19

Holding Valves

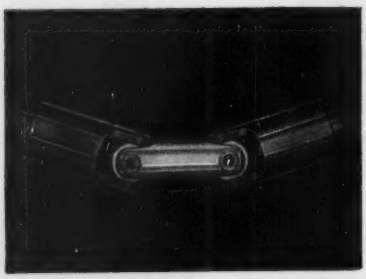
control pressure in hydraulic circuits

Holding valves, designed to control pressure in hydraulic circuits, lock a cylinder or motor when no motion is desired. They prevent load from running ahead of oil supply when load is being moved, and also relieve excessive pressures generated in cylinder or motor by load. In case of power failure, valves permit load to be lowered manually. Valves require little or no power when load is being elevated and

How Curtis helped a design engineer "BEAT THE HEAT"



This single universal joint in a ribbon-stripping machine was operated at a 34° angle. The joint heated up, wear was excessive. (Curtis Joints have been tested at angles up to 37°, but we do not ordinarily recommend angles greater than 30°.)



Curtis engineers recommended a *double* Curtis joint, which reduced the angle to 17° per joint. Result: no overheating, improved efficiency, longer life.

You can depend on Curtis engineering in any problem of angular power transmission. And you can depend on

CURTIS UNIVERSAL JOINTS

because our catalog torque and load ratings are substantiated by constant tests under production conditions.

14 SIZES ALWAYS IN STOCK —
⅜" to 4" O.D. (6" joints on special order)

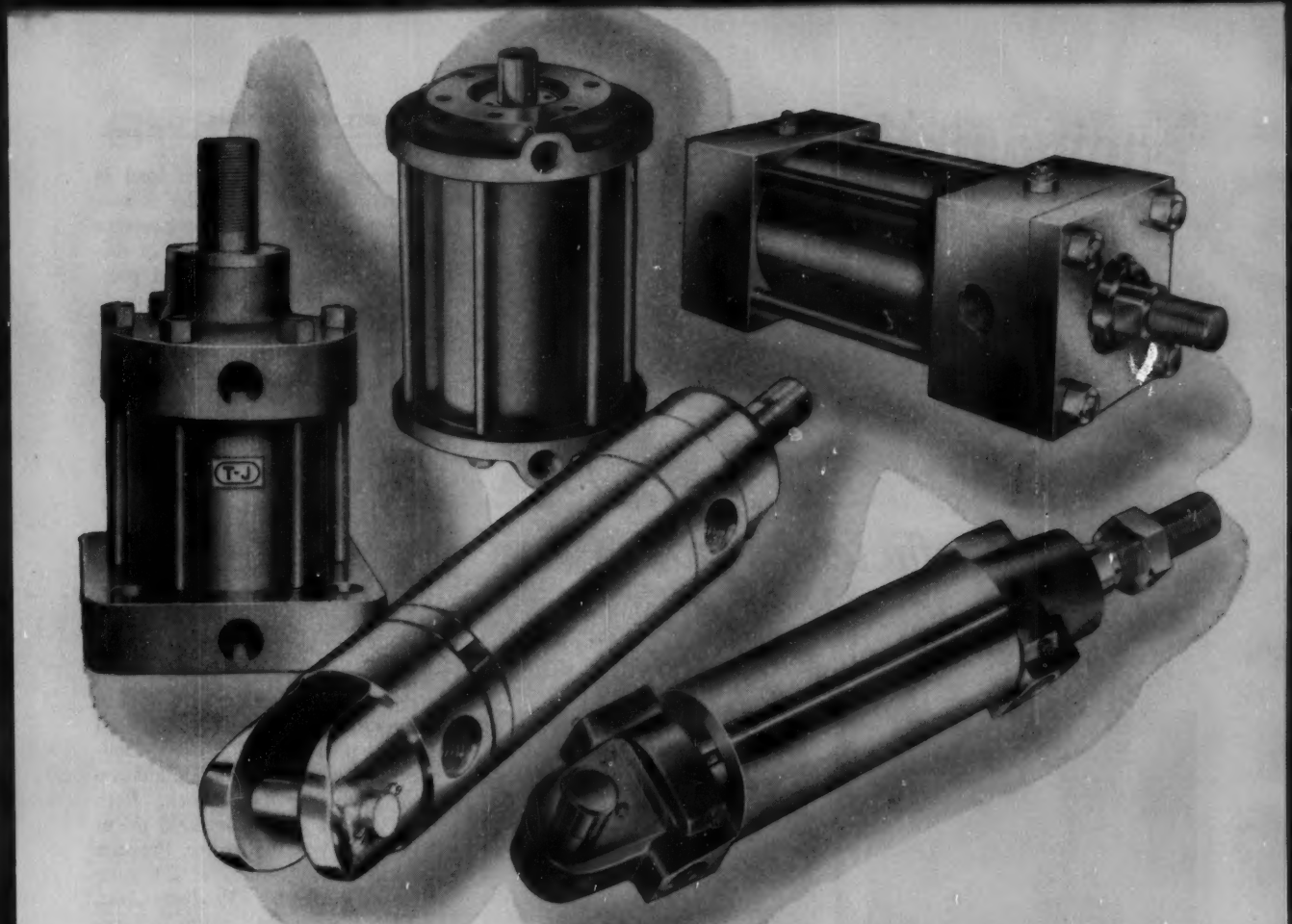
Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.
52 Birnie Avenue, Springfield, Mass.
As near to you as your telephone

EXCLUSIVELY A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

Circle 562 on Page 19



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That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application – with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

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THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.

SQ-1058-4 for the T-J Squair Head cylinder.

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SM-56-3 for the incomparable Spacemaker cylinder.

HSM6-58-4 for the High-Pressure Hydraulic Spacemaker cylinder.

THE TOMKINS • JOHNSON CO. JACKSON, MICH.

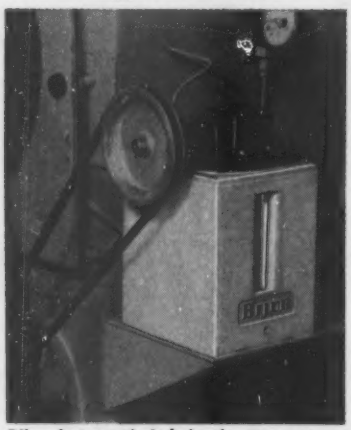
CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS

Circle 563 on Page 19

engineered lubrication, engineered mist coolant equipment by

BIJUR

compact, efficient systems are easily installed, readily adaptable, trouble-free



Bijur Automatic Lubrication is custom-engineered to provide the right amount of oil on an accurate, predetermined schedule . . . filtered, pressure-fed, metered at each outlet point to prevent over-lubrication. The Bijur pump is designed to be an *integral* part of your machine. It can be gear, belt or chain-driven—or independently operated by electrical or hydraulic means.

Bijur SPRAYMIST Mist Coolant Equipment offers many exclusive advantages. Compact *unit* design includes all necessary controls: trap filter, regulator, gauge, solenoid valve and reservoir. No unsightly valves or extra plumbing. Operation is completely automatic—starts and stops with machine. Pressurized reservoir prevents clogging, eliminates siphon-lift problems. Choice of 18 ounce, 1 gallon or 5 gallon coolant capacity.

Bijur Equipment is Standard Equipment in Many Industries

Machine Tools • Business Machines • Printing Machinery • Textile Machinery • Food Product Machines • Bottling Machines • Packaging Machines • Sheet Metal Machines • Plastic Fabricating Machinery • Glass Products Machinery • Wood-Working Machinery • Industrial Sewing Machines • Special Process Equipment

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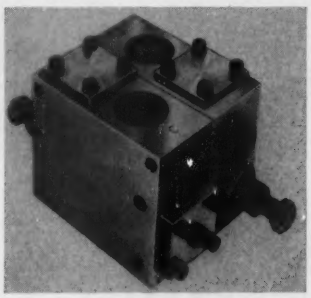
BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

2937

minimum of power when load is lowered. Units lock cylinder or motor, and open with pilot-pressure assist of about 20 per cent of difference between load-induced pressure and valve setting. Single models with external pilot and port are available for use with single-acting



cylinders or for mounting at both ends of double-acting cylinders. Valves are available with Dryseal ¾ or 1-in. pipe NPTF ports. Double models with internal pilots are also available from stock. Both units are for service to 3000 psi at flow of 20 gpm or higher. Pressure drop is about 28 psi at 20 gpm. **Sarasota Precision Products Inc.**, 5757 McIntosh Rd., Route 1, Sarasota, Fla.

Circle 762 on Page 19

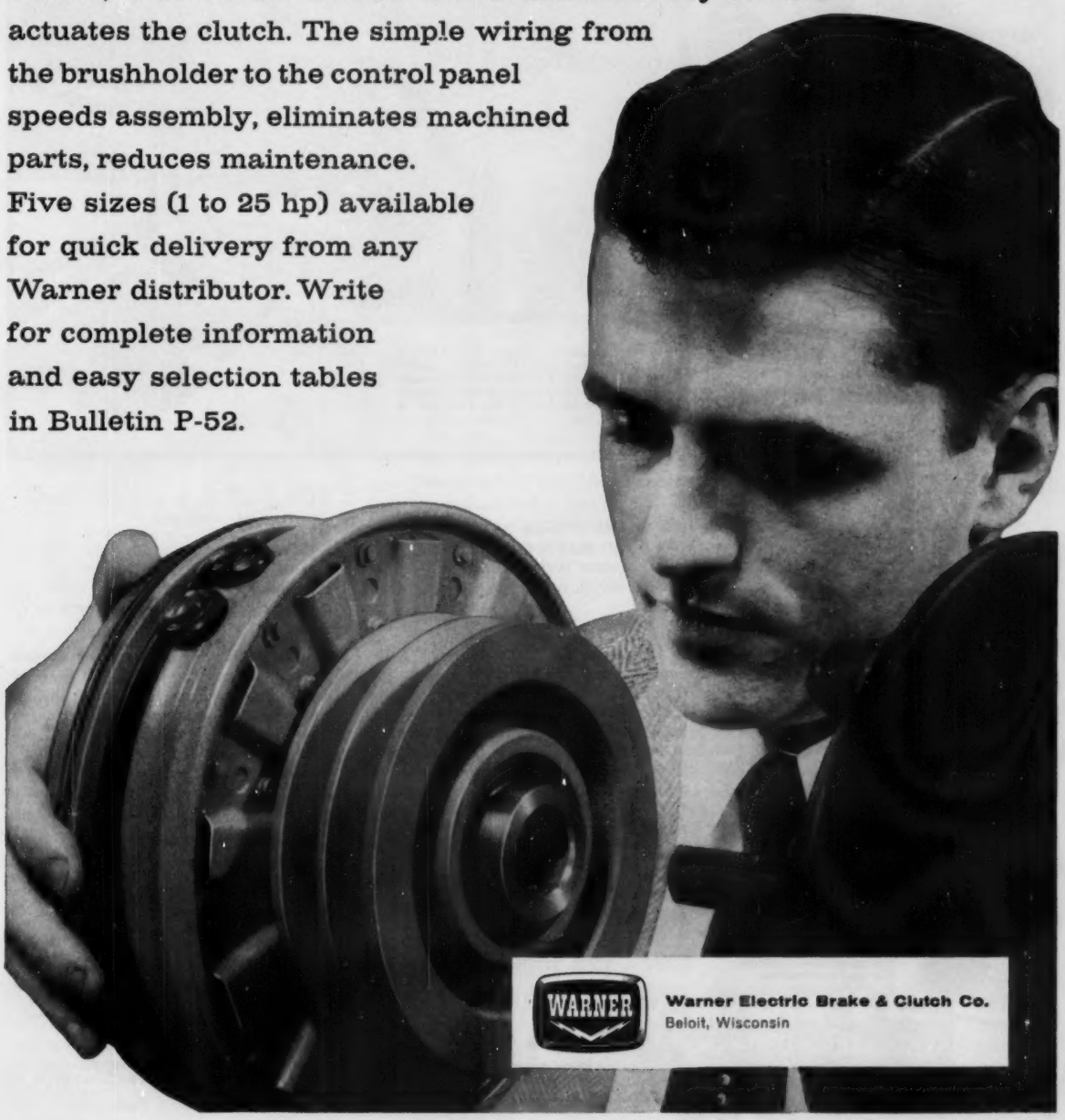
Adjustable-Interval Timer

is pushbutton-actuated, totally enclosed unit

Series AT-36 pushbutton-actuated, adjustable-interval timer is a totally enclosed, motor-driven device designed for use in the control of fans, vending machines, mixers, and photocopying equipment. Housing is of molded phenolic, offering a rigid construction that assures reliable performance under adverse ambient conditions. All terminal and blade configurations are of heavy-gage spring brass without welded or staked joints. Timer is

Special Machinery Builders: Why spend engineering time and money detailing clutches, bearings, drive sheaves, and control equipment when you can buy them in a package? Especially when that package gives you faster cycling, more automatic control, easier pushbutton jogging, and greater versatility! Yes, all the benefits of Warner electric motion control—now practical in every way for one-of-a-kind applications. It's a pre-engineered, completely assembled clutch-pulley combination—Warner's new Electro-Sheave. Just slip it over any standard NEMA motor shaft, tighten the setscrew, mount the brush-holder, and belt the sheave to the machine. Any switch actuates the clutch. The simple wiring from the brushholder to the control panel speeds assembly, eliminates machined parts, reduces maintenance.

Five sizes (1 to 25 hp) available for quick delivery from any Warner distributor. Write for complete information and easy selection tables in Bulletin P-52.



WARNER

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

WEATHERHEAD

fittings and hose assemblies

"MADE BETTER TO SERVE BETTER"

brass FITTINGS

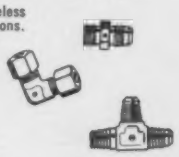
1/8" to 1" sizes for pressures up to 5000 p.s.i. Approved by U.L., A.G.A., A.S.M.E., A.S.A. and S.A.E.

S.A.E. 45° Flare
Compression
Selfalign®
Threaded Sleeve
Inverted Flare
Pipe

forged steel FITTINGS

For flare and flareless pressure connections. Sizes 1/8" to 2" in carbon or stainless steel for pressures to 10,000 p.s.i.

Ermeto
Flare-Twin
S.A.E. 37° Flare
Pipe



bulk hose

Twenty different styles available. From 1/4" to 2" O.D. for working pressures up to 10,000 p.s.i.

hose assemblies

Completely fabricated with permanently attached swaged ends. Any size, any quantity for working pressures up to 10,000 p.s.i.

reusable hose ends

Designed for fast assembly and positive, leakproof performance under high pressures.

tube working tools

Designed for fast, accurate fabrication of all types of tubing layouts.

Tube Cutters
Tube Bending Springs
Mechanical Benders
Flaring Tools
Swaging Tools

Write for new general catalog—contains complete data and specifications for all items.

Screw machine parts made to your specifications . . . any machinable material. Write for information.

AWARD WINNING IDEAS...

Service Minded Equipment Company Uses Ermeto Fittings on Self-Supporting Hydraulic System for "Jeep-A-Trench"

Trenching operations subject digging ladders to varying shock loads. The "Jeep-A-Trench" is equipped with a hydraulic lift which cushions these loads to reduce service and maintenance requirements in the shop and in the field.

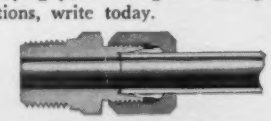
Idea sumbitted by:
Mr. WARREN E. GEORGE
Auburn Machine Works, Inc.
Auburn, Nebraska

In developing the "Jeep-A-Trench", Auburn's engineers considered two important factors: digging in all types of soils subjects any trencher to varying shock loads; and, their equipment must operate in any terrain under all types of conditions. For these reasons, they perfected a hydraulic lift for the digging arm of the "Jeep-A-Trench" that would be as nearly service-free as possible.

"We used steel tubing on our hydraulic system because it withstands greater stresses, does not require the maintenance of rubber covered flexible tubing and it is self-supporting. It is simpler to service," explained Mr. George.

"ERMETO hydraulic fittings were selected because Weatherhead had technical service facilities available all over the U. S. to help service the equipment in case of difficulties."

Auburn is but one of the many service-minded companies relying on Weatherhead fittings for service and reliability. If you desire information or assistance in simplifying your tubing and fittings applications, write today.



ERMETO flareless hydraulic fittings are unmatched for dependability and high pressure control. Available in stainless or carbon steel with "Weathercote" finish. Standard sizes: 1/8 to 2", for pressures up to 10,000 p.s.i.

BRASS & STEEL FITTINGS / HOSE & ASSEMBLIES / TOOLS & ACCESSORIES

WEATHERHEAD

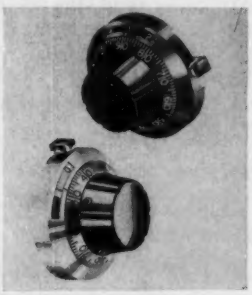
THE WEATHERHEAD CO., FORT WAYNE DIVISION
Dept. MD-2, 128 W. Washington Blvd., Fort Wayne, Ind.
In Canada:
The Weatherhead Co., Ltd., St. Thomas, Ont.

equipped with quick-disconnect terminals for rapid, easy hook-up and ready replacement or repair. Switch on the unit is rated at 28 amp or 1 hp at 250 v ac. Timer is available for 120 or 240-v operation at 50 or 60 cps with intervals of 30 sec and 1, 5, 10, 30, 60, or 120 min. **Haydon Div., General Time Corp.**, 245 E. Elm St., Torrington, Conn.

Circle 763 on Page 19

Turns-Counting Dials

in two new models have 15-turn capacity



Duodial turns-counting dials, Series RB, now include model RBC, which incorporates two set screws, and ebony-finished RBD, designed for applications where black matte finish and white-filled numerals are preferred. Both models are identical mechanically. Working parts consist of two coaxial dials, inner calibrated in hundredths of a turn, outer in full turns. Number of completed turns is clearly visible in a window directly opposite index. Black-nylon knob, integral with inner dial, is directly connected to shaft of device with which it is used, so readings are free of backlash. Capacity of both dials is 15 full turns, with no mechanical stops on either model. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif.

Circle 764 on Page 19

Vane Axial Blower

delivers 200 cfm at 10,500 rpm

Model E2543-200 blower has application wherever maximum air and medium static pressure are paramount. It far exceeds environmental tests set forth in MIL-E-

Chace Thermostatic Bimetal

ACTUATES ANOTHER PRECISION PRODUCT

THE AMERICAN-Standard PRODUCTS THERMOSTAT

A PRODUCT OF AMERICAN-STANDARD
DETROIT CONTROLS DIVISION, DETROIT, MICHIGAN

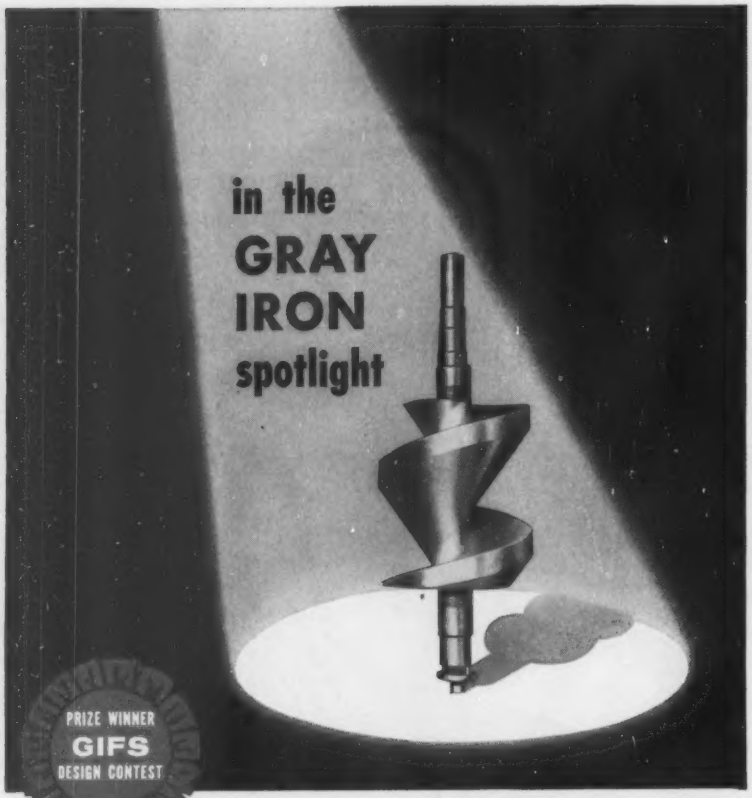
This new thermostat, No. CA 520, a product of American-Standard, Detroit Controls Division, offers the ultimate in style, comfort and dependability. It was designed and manufactured especially for use with American-Standard Furnaces, the "one responsibility" concept. Its features include: hermetically sealed mercury switch; soldered circuit joints and flexible wire; clear plastic base plate for fast installation; five-degree dial calibration and wider selection of temperatures (50° to 90°); and attractive decorator design with concave rim and cover, in bronze and silver, (or paint it yourself). Both the actuating element and the temperature indicating element are Chace Thermostatic Bimetal.

Perhaps sensitivity (or lack of it) is the one feature of a room thermostat most likely to impress the homeowner. One wants to be unconscious of a heating system, not reminded by frequent periods of chill or overheating. The extreme sensitivity and unfailing reliability of Chace Bimetal are the result of Chace's third-of-a-century devoted to the development of efficient alloys and bimetal combinations, plus manufacturing methods and equipment devoted exclusively to the production of precision thermostatic bimetal. Discriminating bimetal buyers can always be certain that their names on the "outside" are safe with Chace "inside."

Chace Thermostatic Bimetal is available in strips, coils and completely fabricated elements of customers' designs — and in more than 30 types. If you have a product in the "thinking stage," send for our booklet, "Successful Applications of Chace Thermostatic Bimetal," for its many pages of illustrated temperature-actuated devices plus much valuable engineering data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 567 on Page 19



Roots-Connersville Achieves 29% Cost Reduction with Integral Rotor and Shaft

The exceptional design freedom in the gray iron casting process frequently enables the designer to reduce costs by converting multiple piece assemblies into one part. Roots-Connersville recently achieved noteworthy savings by redesigning forged steel shafts onto which were pressed ductile iron rotors into a one piece cast part.

Since the rotor hub formerly had to be large enough to key it to the shaft, the redesign results in 41% greater displacement by permitting smaller hub diameters and correspondingly larger outside diameters in the same housing. Machining was reduced from 27 operations to 15.

Start now to re-evaluate your products in the light of integral gray iron castings. Use the experience and know-how of progressive foundrymen, members of Gray Iron Founders' Society, to help achieve outstanding savings.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern
GRAY IRON CASTINGS

Made by Informed Foundrymen!

5422D. Utilizing a 2 5/16-in. diam motor, blower delivers 200 cfm at 10,500 rpm. It operates on a 200-v, 3-phase, 400-cycle source. Blower withstands ambient temperature of 85 C and has life in excess of 5000 hr. Weighing only 3½ lb, it has housing dimensions of 4 in. diam x 4½ in. long. **Air-Marine Motors Inc.**, 369 Bayview Ave., L. I., N. Y.

Circle 765 on Page 19

Air Nozzles

for temperatures from −30 to +350 F

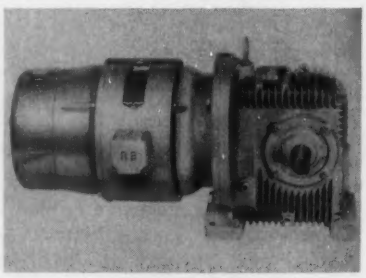
Glass-fiber air nozzles have interior surface smoother than aluminum. They are polished and accurately calibrated for improved nozzle efficiency. Coefficient of expansion is less than metal. Operating temperature range is −30 to +350 F. Sizes range from 9 to 24-in. square mounting base, with throat diameters from 1¼ to 10 in. **Boyle Engineering Laboratory, Div., Rotherm Engineering Co. Inc.**, 7280 W. Devon Ave., Chicago 31, Ill.

Circle 766 on Page 19

Worm Motor Reducers

have full-depth mating between worm and gear teeth

Double-enveloping worm motor reducers utilize worm and gear mating principle which gives full-depth contact of worm and gear teeth, as well as increasing number of teeth



Circle 568 on Page 19

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

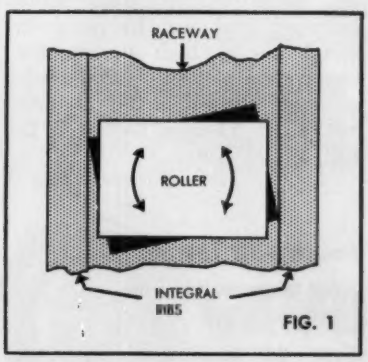
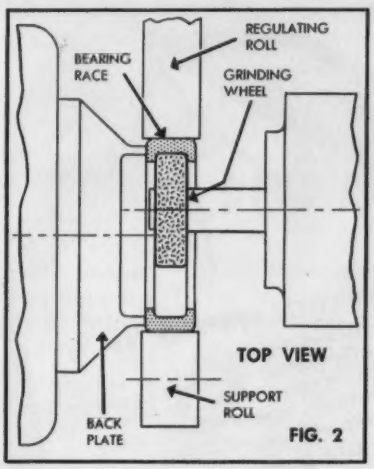
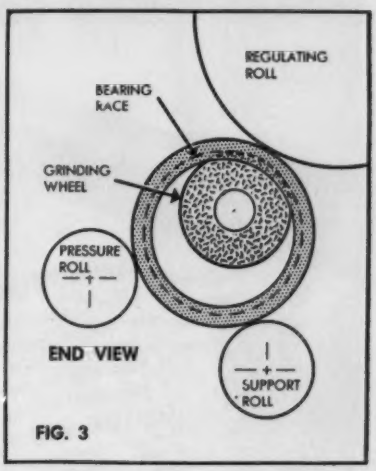


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.



★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

LOW
COMPRESSION
SET
BUTYL!
TECHNICAL MEMO ON LINEAR COMPOUND 7806-70
. . . for O-rings, U-cups and V-rings
• contains Butyl with low compression set plus cold flow properties comparable to other elastomers
• excellent ozone resistance, impermeable to gases
• effective sealing from −65° to +212°F
FLUIDS COMPATIBLE WITH Compound 7806-70
Acetone • Acetylene Tetra Bromide • Alcohols • Ammonium Nitrate
Aniline • Cellulbe • Cinnamon Oil • Cresol • Diethylene Glycol
Diethyl Phthalate • Furfural • Furfuryl Alcohol • Glycerine • Houghto
Safe 271 • Hydrochloric Acid, dilute • Methyl Ethyl Ketone • MIL-H-
19457 • Mobil Nyvac No. 20 • Mobil Nyvac No. 30 • Nitric Acid,
dilute • Nitrobenzene • Oronite 8200 • Ozone • Dimethyl Foramide
Ethyl Acetate • Ethylene Glycol • Ferric Chloride • Fluorolube GR 362
Fluorolube GR 544 • Freon 12 • Freon 13 • Freon 22 • Freon 114
Phenol • Phosphoric Acid • Propyl Nitrate • Pydraul • Silicone fluids
Skydrol • Sod. Hydroxide • Sulfuric acid, dilute • Triethanolamine
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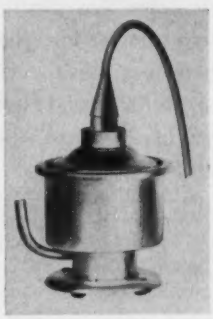
For full technical data — including a list of incompatible fluids, write today for Technical Bulletin No. 56701-1. Linear Inc., State Road and Levick Street, Philadelphia 35, Pa.
"PERFECTION IN RUBBER"
LINEAR
LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA

in mesh. Full-depth mating between worm and gear teeth increases load-carrying contact area almost 100 per cent. Greater contact area reduces unit pressure, so that lighter rated units carry loads ordinarily requiring larger, heavier housings. Motor reducers are available in horsepower ratings from ½ through 15 hp. Speed-reduction ratings, from rated motor speeds, are 525 through 7.3 rpm. Selection of drive motors and brakes can be combined into various power packages. **Reuland Electric Co.**, 3001 W. Mission Rd., Alhambra, Calif.

Circle 767 on Page 19

Small Submergible Pumps

are all-brass design for low cost



Small brass pumps are designed to operate while fully or partially submerged in lubricant fluids, photographic solutions, machine-tool coolants, citrus juices, and a variety of other liquids. The fhp electric pump housings and covers are fabricated from Western Yellow Brass alloy No. 30. Three models are available with capacities from 200 to 514 gph. Pumps are completely sealed in oil and come equipped with molded neoprene cord sets, leakproof terminal blocks, high torque, low-temperature motors, a spring-loaded neoprene oil seal, and a stainless-steel shaft. **Thomas Beckett & Co. Inc.**, Dallas, Tex.

Circle 768 on Page 19

Positive-Off Thermostat

for temperatures from 0 to 650 F

Type AP positive-off thermostat permits cut-out of thermostatic control through manual operation of

from dishwasher tops...to barge skegs...

GAMBLE solves problems with WOOD!

PROBLEM: Wood cutting-board tops of automatic dishwashers were splintering—and even distorting the machines themselves—from tangential swelling and shrinking of the tops.

SOLUTION: Gamble wood engineers developed a strip-constructed board, with edge grain exposed, which is now in volume use.

PROBLEM: The solid wood skegs (outer keel) of assault barges were cracking and splitting on beach landings.

SOLUTION: The *first* laminated skeg was researched and developed—then built in quantity—by Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

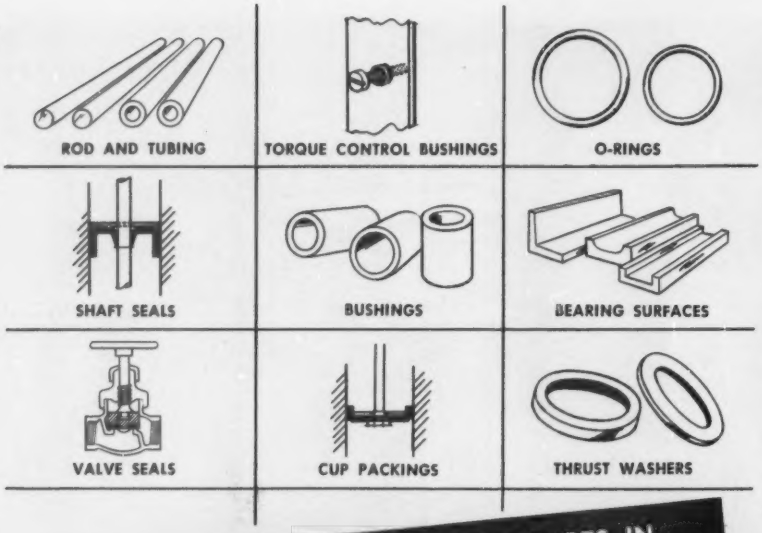
This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave., Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

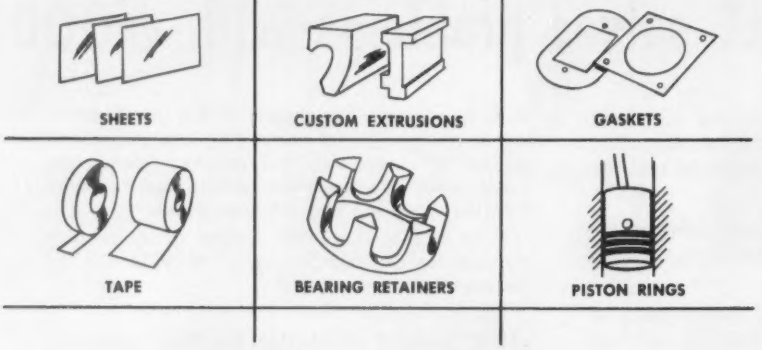


BASIC SHAPES AND FABRICATED PARTS IN

RULON®

REINFORCED TFE RESIN*

*Dupont Teflon



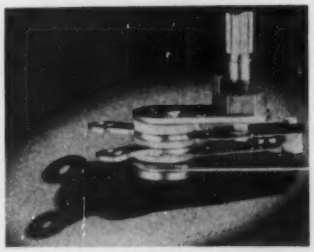
Design engineers note! RULON adds extra values to your products . . . low friction performance even without lubrication . . . wide temperature adaptability (−350° to +500°F) . . . high resistance to wear and deformation . . . and practically universal chemical inertness. Unlike nylon and many other materials, RULON won't swell in presence of moisture.

RULON is the sure relief to many a design headache. For RULON engineering Brochure #9572, write

DIXON CORPORATION
BRISTOL, RHODE ISLAND

Dixon Suppliers of basic shapes and fabricated parts in Rulon and Teflon

Circle 572 on Page 19



adjusting stem. It provides positive make-break control of electrical circuits in response to temperature changes, and is designed for use with appliances, heating and ventilating equipment, vending machines, and manufacturing machinery. Restricting device can be used either to cut out thermostatic control altogether or to limit lower range of operation of thermostat. Unit operates over temperature range of 0 to 650 F and is rated at 15 amp on 115 v ac, 10 amp on 230 v ac. **Norwalk Thermostat Co.**, 52A Woodlawn Ave. N., Norwalk, Ohio.

Circle 769 on Page 19

Liquid-Level Controls

are corrosion resistant

Low-cost liquid-level controls in which all parts of control in contact with liquids or vapors are nonmetallic are designated NM-1 and NM-2 Magnetrols. They control liquids that present problems in handling, such as those with specific gravity of 0.7 or higher. Controls are immune to galvanic or electrolytic attack, are corrosion resistant, and resist oxidizing agents. Smooth surface discourages tendency to scale or act as host for deposits. Controls will not contaminate or impart odors or tastes to liquid. Since construction is of nonflammable and nonsparking materials, controls handle inflammable and

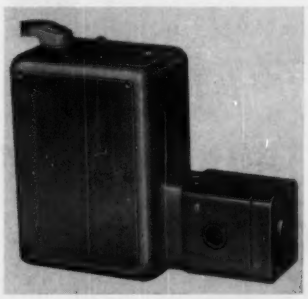
explosive liquids and can be used in volatile fume areas. Polyvinyl chloride is the nonmetallic material used. Chambers and float construction are for service at 100 psi at 70 F, or 50 psi at 140 F. Model NM-1 Magnetrol, shown, is an external-float-cage unit with sealed body and float totally enclosed. Model NM-2 is a flanged-style chamber unit, with head flange secured to chamber by means of a victaulic closure with gasket. **Magnetrol Inc.**, 2110 S. Marshall Blvd., Chicago, Ill.

Circle 770 on Page 19

Solenoid Valve

is two-way high-pressure unit

SV-1 solenoid valve controls pressures from 1000 to 9000 psi. It is a two-way poppet type, normally open to allow circulation of hydraulic fluid through valve and



back to reservoir. Poppet-type construction reduces frictional heat to a minimum. Valve measures 3¼ x 7 x 8½ in. and weighs 8 lb. It is available with either hand or foot switch, and operates on 110-v, 60-cycle current. **Manco Mfg. Co.**, Bradley, Ill.

Circle 771 on Page 19

Digital Modules

for assembling systems without designing circuits

Compatible transistorized digital modules are designed for operation within a temperature range of −45 to +65 C. Wide variety of types includes flip flops, shift registers, multivibrators, one-shots, and dc logic. They are used to assemble digital systems without designing circuits. Features include neon indicators on flip flops and shift regis-

QUALITY TOKHEIM BUILDS PERFORMANCE IN . . . AND MAINTENANCE OUT . . .

IN NEW "MIRACLE METER" WITH

RULON® CUP PACKING . . .

AND 9 OTHER RULON PARTS

TOKHEIM CORP. of Fort Wayne, Ind., leading manufacturer of gasoline pumps, needed a tough material for the cup packing of their new meter's plunger-assembly. Only Dixon's Rulon (reinforced Teflon) had the right combination of chemical *and* physical characteristics to withstand attack from all types of gasoline additives, and *also* stand up under the mechanical stress and wear of millions of plunger cycles. As a result of rulon's performance, it is used in 9 other places as shaft seals, thrust washers and sleeve bearings.

- **RULON resists deformation** — hugs cylinder walls, prevents leakage, maintains meter accuracy.
- **RULON reduces drag**—low coefficient of friction insures smooth operation—even in non-lubricating media (gasoline).
- **RULON wears longer** — tougher than Teflon, Rulon cuts costly maintenance . . . requires no lubrication.
- **RULON is completely inert** — doesn't change properties or swell in presence of liquids.

Look at your designs with RULON in mind. If it's a bushing, bearing, cam, wear strip, or insulator, chances are the combination of the correct RULON formulation plus DIXON's manufacturing capabilities can produce the exact component you need. *One of Dixon's many modifications of DuPont TFE Teflon.

For engineering data sheet 129-8, write . . .

Dixon **DIXON CORPORATION**
Bristol, Rhode Island

Check these outstanding properties of **RULON**

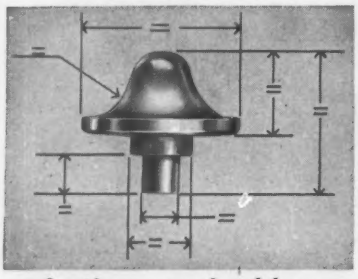
- Resistance to wear: 500 times Teflon
- Low coefficient of friction: 0.10-0.24
- Wide temperature range: −300° to +500°F
- Excellent electrical properties: Resistivity 10^{15}, dielectric constant 2.6, dissipation factor .002
- Chemically inert — Zero water absorption — Weather resistant
- Low coefficient of expansion: 3.3 x 10^{-5} (½ that of Teflon)
- Low deformation under load: ½ that of Teflon

Circle 573 on Page 19

IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

Manufacturers of Cold Headed Fasteners Since 1888

OVER **10** TIMES THE RATE AT **50%** SAVING IN RAW MATERIAL



Another example of how Hubbell Cold Heading produces Better Parts at Faster Speeds, at Lower Cost

THE PART:
Click Button

THE MATERIAL:
Brass

THE METHOD:
Hubbell cold heading in place of screw machining.

THE RESULT:
This brass click button was machined previously from bar stock, involving several different operations that removed nearly 50% of the total weight of the original stock . . . a wasteful, time-consuming, costly process.

Hubbell now produces essentially the same part at tremendous savings in time and material cost.

a. Production is increased from the original rate of 5.5 pcs. p.m. to cold heading rate of 60 pcs. p.m.

b. Labor, overhead and material cost has been reduced 36%.

c. The finished part is stronger, more accurate, with greater uniformity.

Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.

HARVEY HUBBELL, Inc. *Machine Screw Dept.*
Bridgeport 2, Connecticut

Kindly estimate on the enclosed sample (blueprint) Quantity _____

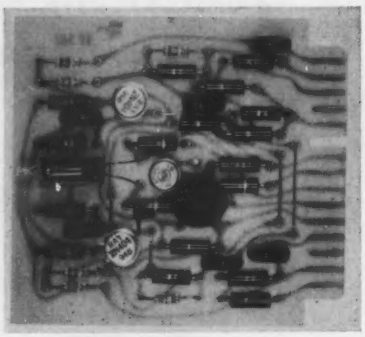
Name _____

Title _____

Company _____

Address _____

Circle 574 on Page 19



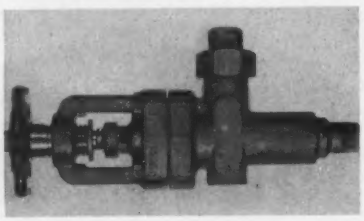
ters, and allowance for use of a remote indicator. Modules have overall size of 3 1/16 x 3⅜ in., with approximate weight of 1.5 oz. Among the applications are digital systems, automation, timing and control, data processing, test equipment, instrumentation, and digital servos. **Control Equipment Corp.**, 19 Kearney Rd., Needham Heights 94, Mass.

Circle 772 on Page 19

Angle Valve

is rated for 4000 psi at 100 F

Angle valve doubles for both liquid-level gaging and instrument piping and general use. No. 74 valve combines features which prevent freezing and eliminate problems of wear from galling in one valve unit built with a minimum of parts. Valve combines advantages of a single-piece, forged-valve body and bonnet flange, to which is mounted a simplified outside screw and yoke-bolted bonnet and a newly designed reciprocating - backseating stem. Construction places threaded portion of stem outside valve body where it is not affected by temperature or nature of liquid being handled. Design allows stem to work freely at all times and prevents possible freezing. Valve has an ASA rating of 1440 lb at 100 F and a commercial rating of 4000 lb. It weighs 8 lb, and is available in



Now in greater lengths

VULCAN
"THUNDERBOLT"
Cartridge Heater

The Vulcan "Thunderbolt" Cartridge Heater is now available in lengths from 1¼" up to 24 inches (or even *longer*) in ⅜", ½" or ⅝" diameters.

The "Thunderbolt" delivers five times more heat than conventional cartridges. Special construction locates insulated resistance wire close to the high temperature alloy sheath. Heat is dissipated rapidly through the sheath without detriment to unit life. Ratings are as high as 40 to 200 watts *per square inch.*

The "Thunderbolt" is ideal for many types of hand and automatic machines that require spot heating. Applications include branding irons, labeling machines, box making machinery, and many others.

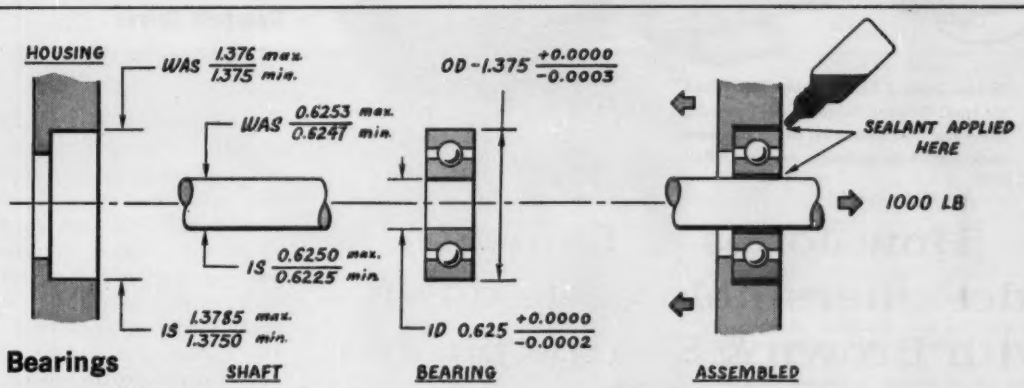
Write for new data sheet.

VULCAN
Versatility in Electric Heating
Vulcan Electric Company, Danvers, Mass.

Circle 575 on Page 19

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning ... provides easier tolerances ... cuts rejects and rework.

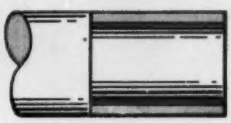


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust ... equal to the best press fit. Slip fit with LOCTITE gives more uniform retention ... eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit ... assures better shaft alignment. Easier tolerances speed assembly.

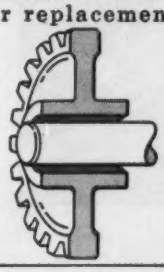
Hardened Sleeves

Eliminates shrink fit ... mounts hardened sleeve without pulling temper.



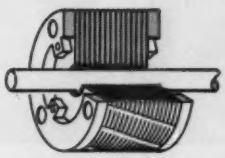
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



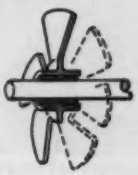
Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws ... no amount of vibration will loosen part.



LOCTITE Sealant is easy to apply... simple to automate

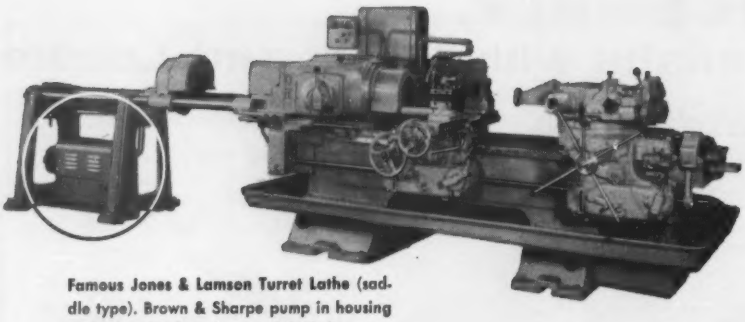
LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared ... stores for years ... hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

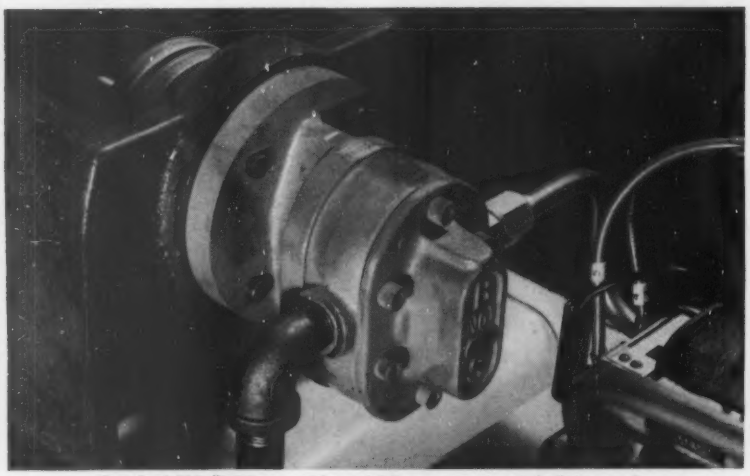
Write for literature and free sample capsule.

LOCTITE® SEALANT AMERICAN SEALANTS CO. 111 Woodbine St., Hartford 6, Conn.



Famous Jones & Lamson Turret Lathe (saddle type). Brown & Sharpe pump in housing under bar feed mechanism (left) helps move stock fast, with minimum operator effort.

How Jones & Lamson designers held costs down with Brown & Sharpe pumps



Standard B&S #1-S Pump, with special flange mounting, is built into each J&L unit. It has quiet helical gears, and needle type antifriction bearings.

Problem: Designers of this lathe needed a dependable pump in the hydraulic unit of the bar feed mechanism. This unit gives "fingertip" control in advancing and chucking stock to be machined. The pump must provide oil pressures to 500 psi, at a capacity of 3¾ gpm; and be flange-mounted and direct coupled to an 1800-rpm motor. Preferably, it should be a "stock" pump, for minimum cost.

Solution: A model 1-S pump with antifriction bearings, from Brown & Sharpe's extra-complete line, meets requirements exactly, with only a minor change made for the customer's flange mounting. Since it is essentially a "stock" item, this pump is very reasonable in cost.

Idea: For the best solution to any pump problem — write Hydraulics Division, Brown & Sharpe Mfg. Co., Providence 1, R. I. Or contact your nearest B&S engineer representative. Brown & Sharpe makes gear, vane and centrifugal pumps to handle more fluids than any other manufacturer.

Brown & Sharpe
PRECISION CENTER

various connections and materials. **Jerguson Gage & Valve Co.**, 80 Adams St., Burlington, Mass.

Circle 773 on Page 19

Gearbelt Drives

in five pitches from 1/5 to 1¼ in.

Gearbelt drives combine flexibility of belt drives with advantages of chain and gear drives. They eliminate disadvantages of slippage, metal-to-metal contact, stretch, and lubrication. Power is transmitted by positive engagement of belt teeth with pulley grooves as in chain drives. Five pitches from 1/5 to 1¼ in. handle a wide range of loads, speeds, and applications at high efficiency. **Browning Mfg. Co.**, Maysville, Ky.

Circle 774 on Page 19

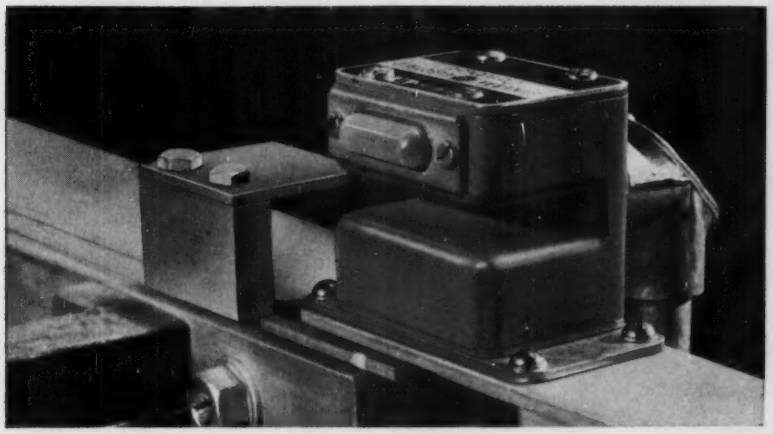
Flexible Shafts

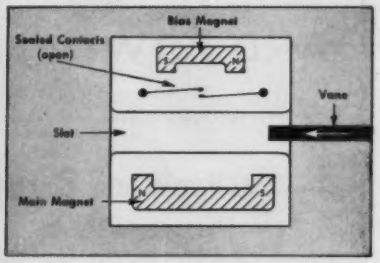
for heavy-duty use

Two extra-heavy-duty, power-drive flexible shafts transmit high torque over any curved path. S100 flexible shaft, with 1-in. diam core, transmits up to 760 lb-in. of torque at 600 rpm; S125 shaft, which has 1¼-in. diam core, transmits up to 1650 lb-in. of torque at 500 rpm. Heavy-duty core is made up of layers of tightly wound, high-grade music wire. Flexible casing is lined with oil-tempered spring steel, reinforced with wire braid, and covered with an oil-resistant, neoprene-impregnated fabric and an abrasion-resistant rubber jacket. Shafts have a square slip coupling at one end with enough play to take care of slight changes in length due to varying torque loads. Couplings of various bores are available for connecting up at each end. **Stow Mfg. Co.**, 11 Shear St., Binghamton, N. Y.

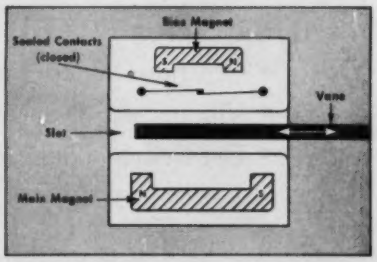
Circle 775 on Page 19

NEW vane-operated limit switch helps industry solve major electrical problem: limit switch life





On normally open form, bias and main magnet flux are balanced at the switch, causing it to remain open. As vane enters the slot, flux of the main magnet is shunted to the lower reluctance path offered by the magnetic material in the vane.



As vane passes the center of the switch, enough flux shunts from the main magnet to cause the flux of the bias magnet to close the switch. Withdrawing vane from the slot reverses the conditions and causes the switch to reopen.

GENERAL ELECTRIC'S ENCAPSULATED DESIGN SEALS OUT CONTAMINANTS; HAS NO ARMS, LEVERS, OR SHAFTS

General Electric's new vane-operated limit switch design surmounts most of the operating problems that cause failure in today's conventional limit switches. The unique new limit switch performs the position-detection function of conventional switches and *eliminates physical contact with the moving object.* It has no shafts or arms to fail, no sliding or rotating parts to wear, no shaft seals to leak.

This means that the operating life of the vane-operated limit switch is not affected by such tough application requirements as frequent operation; hammering of lever arms and mechanisms; lever arm "snapback"; mechanical wear; and splashing and spraying of coolants, lubricants, and other contaminants.

REASONS FOR LONGER LIFE

Contributing to the extremely long life of the new device is the encapsulation of all internal components in a cast aluminum enclosure. This means liquids, dirt, or metal chips cannot enter the switch mechanism and cause operational failure.

In addition, the only moving parts in the new design are magnetic reed contacts hermetically sealed in an inert gas. Thus, switch life is determined almost solely by contact load. When used with small a-c relays, such as the G-E CR2790 general purpose type, the expected operating life of the switch is from 30 to 50 million operations. It is capable of over 250 million operations when operating General Electric static control circuits.

The inherently longer life of the new vane-operated limit switch results in savings from greatly reduced maintenance and replacement expense and less downtime. And the new switch costs about one-third less than proximity switches, making it only slightly higher in price than a conventional limit switch.

HOW IT WORKS

The vane-operated limit switch is energized by passage of a separate steel vane through a recessed slot in the switch (see illustrations at right). The vane is attached to the mechanism to be controlled. As the vane passes through the slot, it changes the balance of the magnetic field, causing the contacts to operate. The contacts are hermetically sealed in an inert gas to prolong life.

The new switch is easy to install. It can be front- or top-operated and can be used to control linear or rotary travel. In addition, the base plate can be rotated 90° to provide mounting flexibility. Both normally open and normally closed forms are available with or without an indicating light. The new limit switch is 25 percent smaller than previous models, and it requires no separate power supply or amplifier.

The switch can detect very high speeds of vane travel without detrimental effects such as arm or mechanism wear or breakage. The switch also offers excellent accuracy and response time. Providing the path of the vane through the slot is constant, trip point repeatability is constant within plus or minus 0.0025 inch. The switch response time is approximately one millisecond.

MEASURABLE ADVANTAGES

Vane-operated limit switches hold significant and measurable operating advantages over conventional limit switches. These advantages can be measured by the maintenance and replacement savings they can produce, and deserve serious consideration on limit switch applications.

For more information contact your G-E sales office or request bulletin GEA-6995 from General Electric Company, Schenectady, N. Y. 813-8

GENERAL ELECTRIC

You get
MEASURABLE ADVANTAGES
with General Electric control.

NOW AVAILABLE

TWO HELPFUL BOOKLETS ON ELECTRIC MOTORS AND POWER SUPPLIES

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A symposium of six articles on the selection, specification and application of—

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- AC and DC Electric Generators
- Lightweight Electric Generators
- Generator-Battery Systems
- Vibrator and Dynamotor Power Supplies
- Dry Cells and Storage Batteries

$1.00 a copy

2. Special Report on Electric Motors

Including a 10-page Directory of 140 motor and gearmotor manufacturers, classified according to the types of motors produced.

A comprehensive review of the design advances in electric motors, with special articles written by authorities in the areas of fractional and integral horsepower motors.

$1.00 a copy

MACHINE DESIGN
READER SERVICE

Penton Building
Cleveland 13, Ohio

Remittance or Company Purchase Order must be enclosed with order

Name

Company

Address

City Zone State

Send me____copies of Power Supplies
Send me____copies of Electric Motors

(Add 3% to orders in Ohio to cover State Sales Tax)

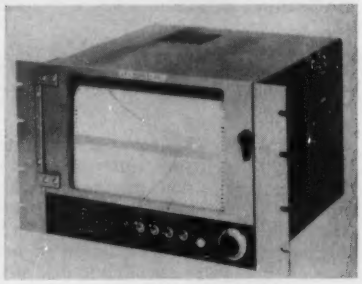
ENGINEERING DEPARTMENT

EQUIPMENT

Strip-Chart Recorder

has six chart speeds from 2 to 60 ipm

Strip-chart recorder, Model 80A Autograf, provides instant selection, through transistor switching, of six chart speeds. Full-scale sensitivity is 0.05 per cent, and resolution and accuracy is 0.2 per cent. Six chart speeds of 2, 4, 6, 8, 15, and 60 ipm are selected instantly by front-panel pushbuttons. Input range of



5 mv to 100 v is covered in ten steps, or by vernier for completely continuous span voltage control. Instrument has a full-range zero set and provides pen speeds to 0.25 sec full scale. It employs standard 120-ft chart rolls. F. L. Moseley Co., 409 N. Fair Oaks Ave., Pasadena, Calif.

Circle 776 on Page 19

High-Speed Camera

small-size unit weighs 40 lb

Portable high-speed framing camera weighs only 40 lb and occupies about as much space as an oscilloscope. Model 1 camera features box-camera simplicity of operation and maintenance. It uses special image-converter type tube shutters. The all-electronic shutter has a speed range of 0.1 to 10 microseconds; other ranges can be provided. A separate shutter tube and objective lens is used for each exposure, providing the equivalent of four completely independent cameras. Focus and

U.S. Rubber fenders of Enjay Butyl taking a 2000 horsepower push without damage to ship or dock! Installed on #7 Oil Dock, Nueces County Navigation District, Corpus Christi, Texas.

ENJAY BUTYL

Dock bumpers absorb 2000 H.P. "nudge"...no damage!

Wham! A heavy freighter bangs into dock fenders of Enjay Butyl rubber. Flattens them 7 inches before stopping. No damage anywhere – to the vessel, the dock or the Butyl! Enjay Butyl absorbs shock and damps vibration better than any other rubber. It does a wonderful job in auto body mounts, tires, truck "load cushions" that replace springing . . . even safeguards missile parts in launching.

Enjay Butyl outperforms other rubbers in many other ways, too. Provides long-term resistance to chemicals, heat, ozone, weathering, moisture, abrasion, flexing and tearing. Unmatched in electrical properties. Famous for impermeability to gases. You can find out how versatile Enjay Butyl can help improve your product, by contacting your nearest Enjay office.

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EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

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Circle 580 on Page 19

? WhaT

WHAT? . . . An entirely new concept in socket set screws—capable of delivering the highest degree of holding power ever attained . . . is now available! The new P-K® W-POINT provides 30% more back-out torque . . . 50% more resistance to vibration . . . 50% more resistance to rotary slippage!

Why ?

WHY? . . . Because ordinary cup point set screws fail to meet today's exacting application requirements, and the increasing demand for component reliability. Because of the pivot point built into the cup, the W-POINT tracks cleanly and uniformly. Its impression upon the work is even in depth and shape at all points on the circumference, producing intimate frictional contact on both flanks of the cup. The new P-K W-POINT reduces "wobble" caused by the required tolerance clearances between screw threads and the tapped hole—minimizes the "tipping" effect of key tightening—contributes increased contact areas for stronger, more dependable holding power than ever before possible.

HOW MUCH ?

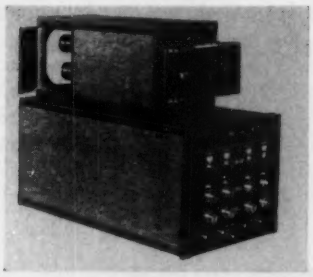
HOW MUCH? . . . Not one penny more than conventional set screws. You get all the advantages of this revolutionary improvement in socket set screws—*at no increase in price!*

the new W-POINT SOCKET SET SCREW by PARKER-KALON®

T.M. U.S. PATENT NO. 2,907,245

Perhaps your engineering department would like to test the new W-POINT. Ask your P-K Industrial Distributor for complete information and samples, today, or write to P-K direct for technical bulletin No. 1106.

PARKER-KALON, *a division of General American Transportation Corporation. Clifton, New Jersey. Offices and Warehouses in Chicago and Los Angeles.*



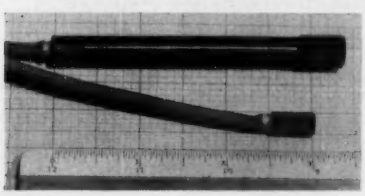
aperture adjustments are completely independent for each channel. Each of the four channels has an independent time delay adjustable from 1 to 1000 microseconds. The four photos can be taken in sequence or simultaneously. Equipped with four f1.4 Nikkor 50-mm objective lens, the camera uses a Wollensak 75-mm, f1.9 recording lens. The camera takes pictures in color or black and white, including self-illuminated objects such as explosives and electrical discharges. For hazardous locations the camera head can be operated remotely. **Abtronics Inc.** 64 South P St., Livermore, Calif.

Circle 777 on Page 19

Temperature Sensor

for precise-location measurement

Delta-Couple Model B1 is for accurate temperature measurements with a minimum of thermal disturbance at precise in-wall locations of steel structures having a section thickness of 1/4 in. or greater. Standard sensor is available with body materials of 1020, ASTM-A7, or 4130 steels, and 303 stainless steel. Chromel-alumel is standard junction material. Leads are 10 in. long, No. 28 B&S-gage wire, glass-asbestos insulated. Body has a 3/8-24 NF-2 thread for installation. Body lengths are available in 1/8 in. increments from 1/4 to 3 1/2 in. Thermocouple - junction location, which is determined to ±0.002 in. or less, is available in standard increments of 1/8 in. from 0.001 in. of heated surface to 0.005 in. from unheated surface. Units are individ-



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Mechanical Shaft Seals
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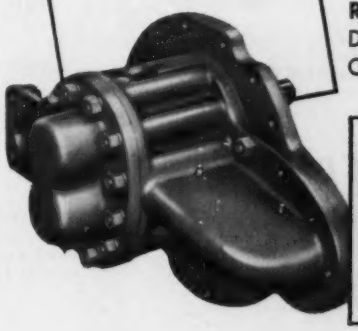

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Whether your problem is high pressure, low pressure, capacity, size or weight — Roper has solved requirements like these for many customers. Let us go to work on the pump for your application. Write or call us today.

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COMMERCE, GEORGIA

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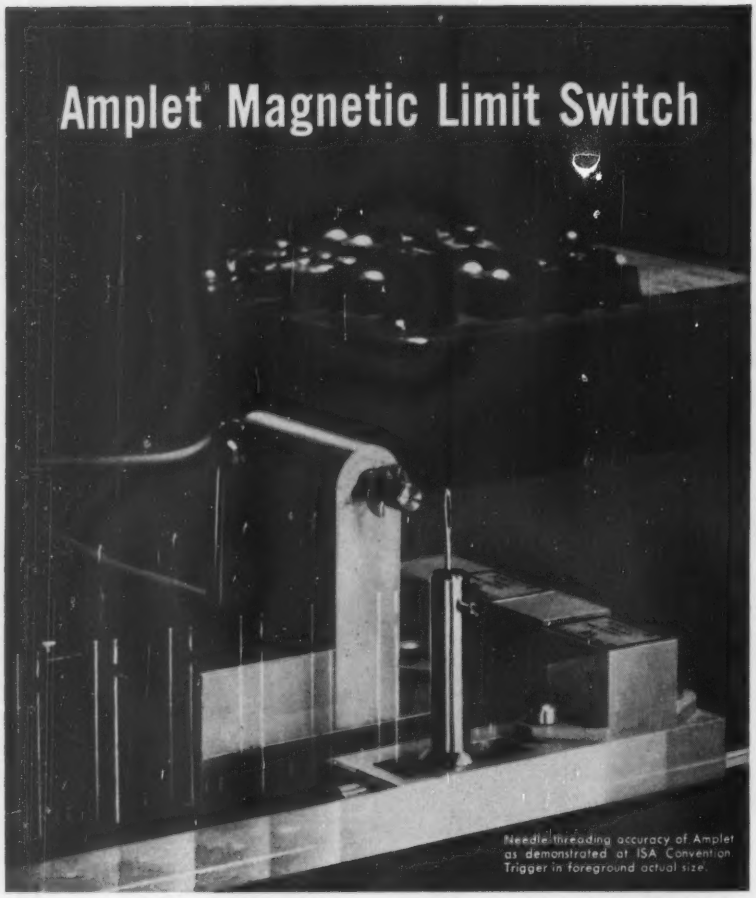
ROTARY PUMPS

Circle 582 on Page 19


Amplet Magnetic Limit Switch
Needle threading accuracy of Amplet as demonstrated at ISA Convention. Trigger in foreground actual size.

9 times more accurate than conventional proximity systems

This new Amplet® Magnetic Limit Switch operates with uncanny accuracy . . . 9 times more accurate than conventional proximity systems. It acts on the proximity of two miniature sensing elements . . . and provides a new standard for precision control of all types of machine motion.

Amplet meets the most rigid specifications for long life, environmental conditions and continuous accuracy. Check these important features . . . • High repeat accuracy, to ±.001″ on successive approaches • Adjustable differential as low as .002″ • Differential accuracy is maintained within ±.001″ • True snap action . . . 1 millisecond response time • Nothing to wear out, static devices are used throughout • Trigger distance variable from .020 to .200″ for "on" signal, greater distances available on special order.

Amplet has only three basic parts. A probe mounts on a stationary part of the machine, a magnetic trigger mounts on the moving part and becomes the actuating element, and the amplifier boosts the probe signal to useful levels. Probe and trigger are completely free from environmental and shock conditions.

APPLICATIONS

The Amplet Magnetic Limit Switch can handle a wide variety of motion control:

• Machine Tools — Limiting cuts or traverse on shaper, planer, automatic drill press.

• Transfer Machines — Position stop on multi-station transfer conveyor.

• Automated Production — Continuous sequencing and counting.

• Measurements — Automatic weighing and filling.

FIND OUT ALL ABOUT THE NEW AMPLET . . . . Complete specifications, application information and sensitivity characteristics are available for you now. Call or write, today.

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ually packaged, and thread sealant, detailed instructions, and a spanner wrench are furnished with each order. **Advanced Technology Laboratories, Div. of American-Standard,** 369 Whisman Rd., Mountain View, Calif.

Circle 778 on Page 19

Environment Chamber

has range of −125 to +350 F

Mobile environmental chamber, Model AF-1.5-125+350, has a range from −125 to +350 F. Entrance ports at the door for instrument cables eliminate feed-through ports and terminal panels. Temperatures can be lowered from +350 to −100 F in 50 minutes, and raised from −100 to +350 F in 30 minutes. Accuracy is ±2 deg F. Features include a 24-hr recording chart, interior lighting, multipane thermal glass assembly in the door, hermetically sealed heating elements, safety controls, stainless-steel interior, 16-gage steel exterior with baked finish. Power requirements are 200 v, single phase, 60 cycles; or 220 or 440 v, three phase. Interior dimensions are 14 x 14 x 14 in. Floor space is 26 x 32 in. **Webber Mfg. Co. Inc.,** Box 217, Indianapolis 6, Ind.

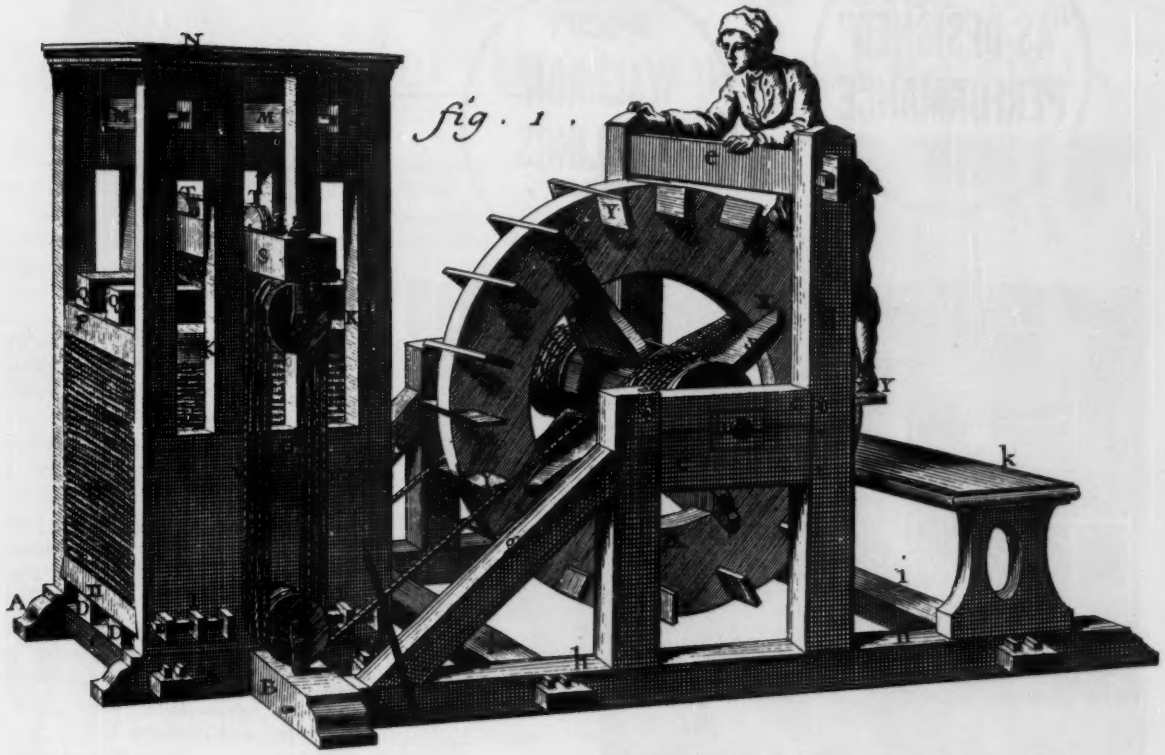
Circle 779 on Page 19

Rack-Mounted Oscillograph

has modular construction for flexibility

Type 5-123 oscillograph mounts on standard 19-in. relay racks. It can be built to a variety of configurations and specifications by assem-

* WHO NEEDS AUTOMATION?



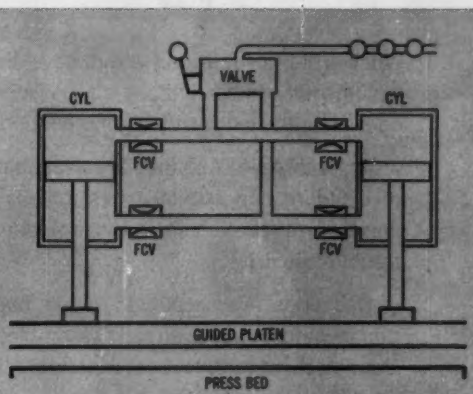
...The way we do it now works fine

This was the latest thing in baling presses in 1752. It worked fine then, and probably would today—provided you could afford the operating time and cost.

What about the way *you* put pressure on things that have to be compressed, squeezed, flattened? If you're not using Fluid Power, you may well be hours and dollars ahead to investigate the Modernair way *now:*

PROBLEM: To operate the platen of a press to compress and hold bundles of folded cartons for strapping prior to shipment.

SOLUTION: *Two Modernair cylinders operated in parallel by a single Modernair hand lever operated, spring centered 3 position 4 way valve. In "advance" position, valve admits air to main cylinder area to advance piston rods. When desired pressure is reached, operator releases handle and valve is spring-returned to neutral. In this position, all ports are blocked and platen is held in advanced position until load is strapped. Operator then moves valve to "retract," air flows to net cylinder area, lifting platen to starting position.*



44

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FOR
"AS DESIGNED"
PERFORMANCE
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SPECIFY
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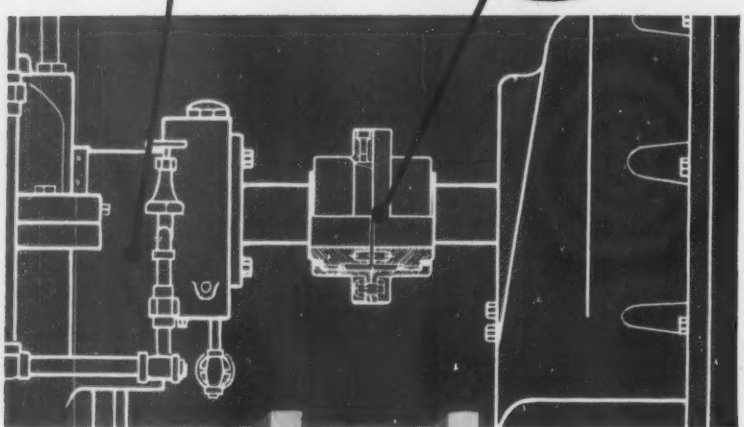

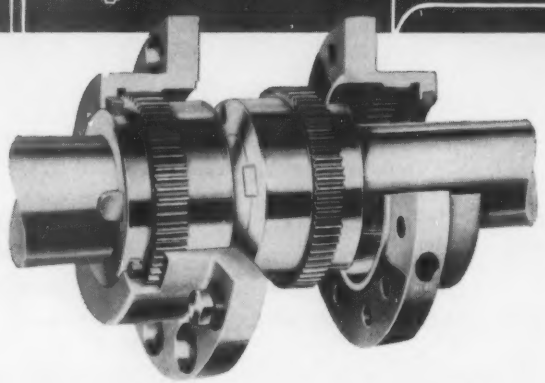

When a lot of time and effort have been put into the design of a driven unit, it makes sense to protect its operating efficiency with a good coupling.

Waldron gear couplings are available in a wide range of standard and special types for any service requirement, to provide complete protection and positive, trouble-free drive.

Deliveries are excellent. Rough bore standard couplings up to 6" sizes, already assembled, can be shipped from stock; others, to meet customers' schedules.

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bling a combination of modules, including mounting, record transport, optical, drive, and front-panel controls. Universal, independent wiring harness makes possible electrical interconnection with only a screwdriver. Basic number of channels is 36 and 50, with other sizes possible by changing magnet blocks in optical module. Variety of record speeds from very slow to 160 ips is possible with drive module. Direct viewing of writing trace is provided at all times. Standard paper is 12-in. wide, direct-printout type, and capacity is 475 ft of thin-base paper. **Consolidated Electrodynamics Corp.**, 360 Sierra Madre Villa, Pasadena, Calif.

Circle 780 on Page 19

Indicator

is differential transformer type

Accurate indication and recording of static and dynamic values of linear motion, acceleration, force, pressure, strain, and other quantities measurable by differential-transformer transducers are achieved with Model 300BF differential transformer indicator. Demodulated output, flat to 500 cps, is available for operation of cathode-ray and recording oscillographs. Static, slowly varying, and average values are displayed on a 10-in. Weston panel

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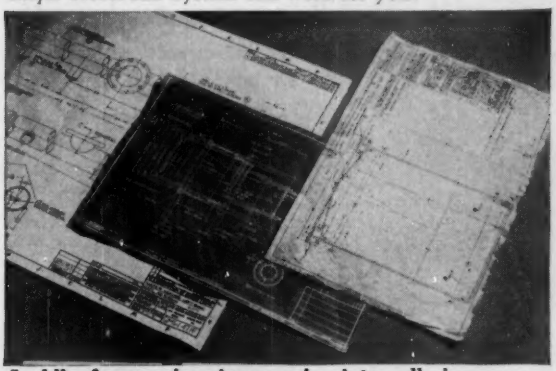
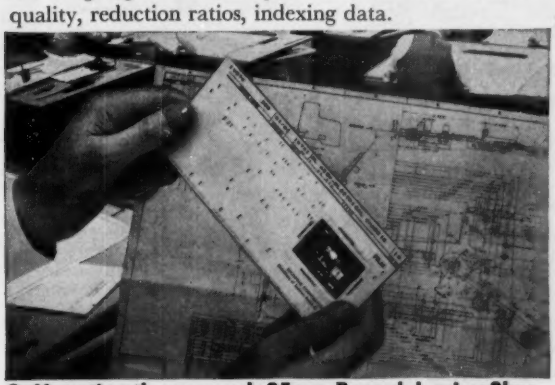


1. All of your drawings and prints—all sizes, ages, colors—are reproduced with needle-sharp line detail and remarkably uniform backgrounds on low-cost 35mm Recordak microfilm. New Recordak microfilming techniques and quality control methods are responsible for outstanding results which more than meet the most rigid government specifications for resolution quality, reduction ratios, indexing data.



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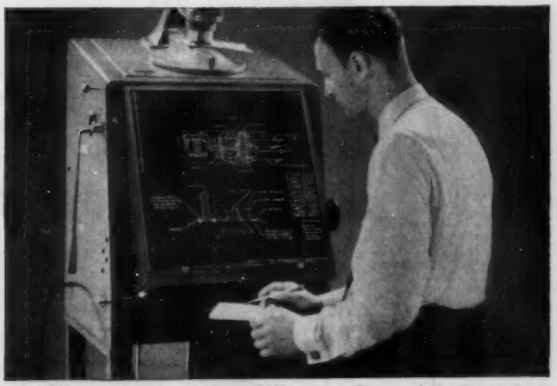

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Free booklet—"must reading" for every engineer and draftsman—gives further details on this new system, available through Recordak.

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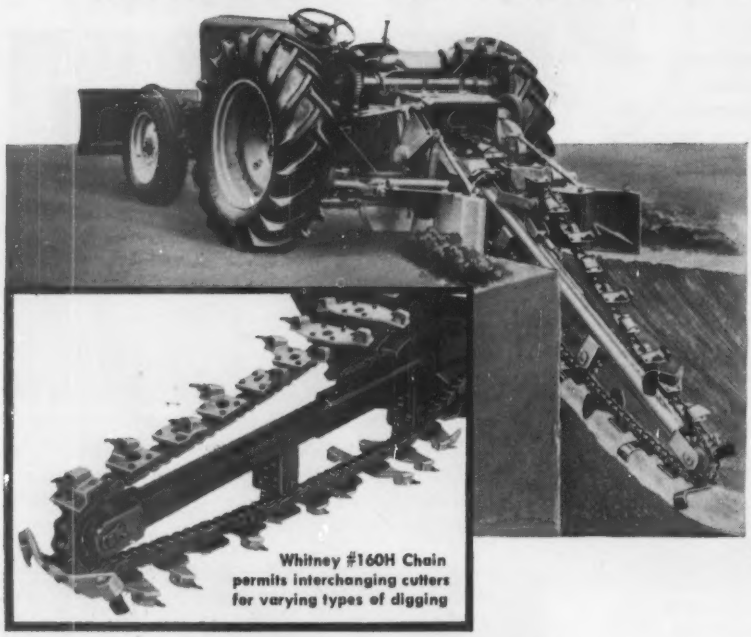
When ARPS Corporation Needed RUGGED, LONG-LIFE CHAIN —WHITNEY was the Choice!



Whitney #160H Chain permits interchanging cutters for varying types of digging

Heavy Duty "TRENCH HOG" Delivers Maximum Performance

When ARPS CORPORATION engineers were designing the "Trench Hog" trencher, they knew that extreme demands would be put on the drive chain and especially the digging chain which carried the cutters. Users don't baby equipment like this, and they expect it to stand up under long, hard service—no matter how tough the digging.

Arps engineers selected Whitney #160H Chain for the digging chain and standard Whitney Chain in 3 sizes for drive chain. After more than 10 years of experience with thousands of units in the field, here's the record: **Arps has never received a complaint on the "Trench Hogs" chain performance.**

Whitney Chain is superior performance chain because every detail of Whitney Chain production involves careful quality control and the use of the most advanced chain manufacturing techniques. More is put into every Whitney Chain to insure that the user gets more out of it.

Whitney Chain is sold and serviced by a network of strategically located Distributors who can provide expert help in solving any chain drive problem. Ask them, or write for the Whitney Chain Catalog.

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a subsidiary of FOOTE BROS. GEAR AND MACHINE CORPORATION
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POWER TRANSMISSION DRIVES

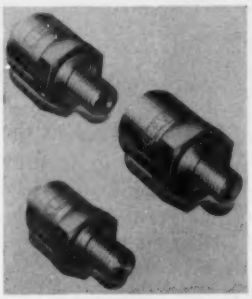
meter. Instrument features an internal excitation supply, self-checking features which eliminate drift errors, and five calibrated sensitivity ranges which cover usual scientific and industrial requirements. Accuracy is 1 per cent with maximum resolution of 0.000005-in. of core displacement. **Daytronic Corporation**, 225 S. Jefferson St., Dayton 2, Ohio.

Circle 781 on Page 19

Self-Generating Accelerometers

for maximum acceleration of 5000 g

Self-generating accelerometers feature 500 F temperature operation and less than 3 per cent cross-axis (lateral) sensitivity. Units are available for missile and aircraft vibration testing and for general



industrial measuring applications. Features include maximum acceleration of 5000 g, hermetically sealed case, high output for given capsule size, and accurate calibration for reliable repeat measurements. **Clevite Electronic Components**, 3405 Perkins Ave., Cleveland 14 Ohio.

Circle 782 on Page 19

Large-Screen Oscilloscope

has 17-in. cathode-ray tube

Large-screen oscilloscope with 17-in. cathode-ray tube performs various oscilloscope functions with high degree of resolution and accuracy. It is especially suited for computer readout observation. Oscilloscope incorporates 10 mv per in. sensitivity, highly stabilized input amplifiers for drift-free operation, accurately calibrated controls for over-all 2 per cent accuracy. **EPR Special Products Corp.**, 675 Barbey St., Brooklyn 7, N. Y.

Circle 783 on Page 19

A Tiny Producer, the honeybee, is equally famous as a supplier of a favorite delicacy and as a pollinator of valued crops. Worker bees — the only nectar-gatherers, honey-processors and home-builders — are always the smallest members of their colony. About ½" long, they're considerably smaller than drones.

Small Pain-Reducer. In this newest dental handpiece, tiny MPB bearings permit the head to be miniaturized for easier use and better visibility, particularly with children. The MPB bearings used here must withstand punishing acceleration from 0 to 250,000 rpm in a half-second, the speed necessary for comfortable, quiet drilling.

Man With Miracles. Every day MPB Sales Engineer Ray Armstrong helps industrial and scientific engineering staffs to select miniature bearings that reduce friction and increase accuracy of instruments and other devices. An MPB sales engineer is always ready to help you develop the miniaturization your products need.

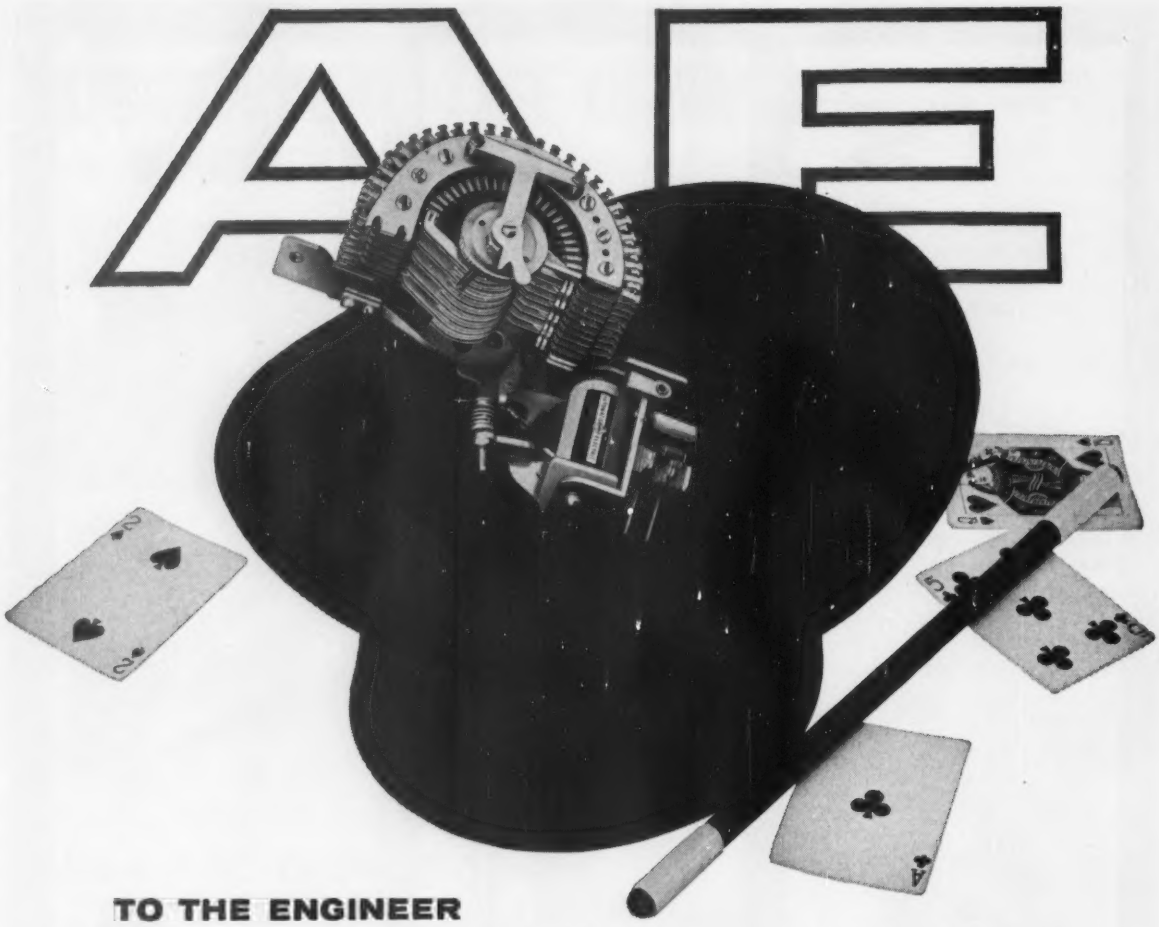
Miracles in Miniaturization

ACTUAL SIZE OF THE MPB BEARINGS IN DENTAL HANDPIECE SHOWN ABOVE

More Miniaturization Than Ever. Even in the dimmest past, reductions in size have been absolute necessities to meet certain needs. Today, outer space exploration and many other modern projects call for miniaturization on a greater scale than ever. MPB, continuing as the foremost pioneer in this field, produces over half of the nation's supply of miniature bearings, including over 500 types and sizes, ranging down to 1/10" O.D., with specials as required. For a catalog with complete details, for engineering assistance or for both, write **Miniature Precision Bearings, Inc.,** 102 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

Circle 588 on Page 19



TO THE ENGINEER

who can use a little honest trickery

There's more than one way of skinning a cat —or making ideas *work* automatically. And AE has a bag-full.

That's because AE has had years of experience in making relays and stepping switches work wonders in automatic telephone exchanges—*and* in automatic control devices.

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For instance, the AE Type 45 Stepping Switch, illustrated, has a free-floating pawl that never binds, never breaks, eliminates the necessity of ever readjusting armature stroke, does away with double-stepping or overthrow. And the switch usually outlasts the equipment it's built into!

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Want more information? Just write the Director, Industrial Products Engineering, Automatic Electric, Northlake, Illinois. Ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

AUTOMATIC ELECTRIC

Subsidiary of
GENERAL TELEPHONE & ELECTRONICS

Circle 589 on Page 19

THE ENGINEER'S Library

Recent Books

Oil Hydraulic Power and Its Industrial Applications. *By Walter Ernst; 467 pages, 6¼ by 9¼ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$12.50 per copy postpaid.*

Generation, utilization, transmission, control, and applications of oil hydraulic power are general areas of discussion. Basics of fluid mechanics, component and circuit design, and information on equipment, operation, and maintenance are covered. This second edition includes new material on petroleum-base and synthetic hydraulic fluids, hydrodynamic effects in rotating fluids, hydrostatic bearings, pump noise and vibration, and servomechanisms.

Mechanisms and Motion. *By K. H. Hunt, Senior Lecturer in Mechanical Engineering, University of Melbourne, Australia; 114 pages, 5¾ by 8¾ in., clothbound; published by and available from John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; $4.25 per copy.*

Conventional graphical methods of mechanism analysis are rationalized by means of vector applications. Also, an introduction to space mechanisms is presented. Vector methods in kinematics, hinged plane mechanisms, degrees of freedom, and plane mechanisms with sliding and higher pairs are some general topics of discussion.

Engineering Statistics. *By Albert H. Bowker, professor of mathematics and statistics, and Gerald J. Lieberman, professor of statistics and industrial engineering, Stanford University; 585 pages, 6¼ by 9¼ in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$11.00 per copy postpaid.*

Application of modern statistical theory to engineering and physical sciences is covered. Fundamentals

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engineering for **both** cost and mechanical requirements in the bearing field . . .

Bunting can help you identify and procure the bearing or part that will do your job at the lowest possible cost. Often a re-examination of the actual mechanical needs of a bearing application reveals an opportunity to save money in design. Another saving is almost invariably achieved by considering ALL the new bearing materials which Bunting makes available to you today. Let Bunting help you engineer your bearing application in the light of modern availabilities. Send in your blueprints or ask for engineering counsel.

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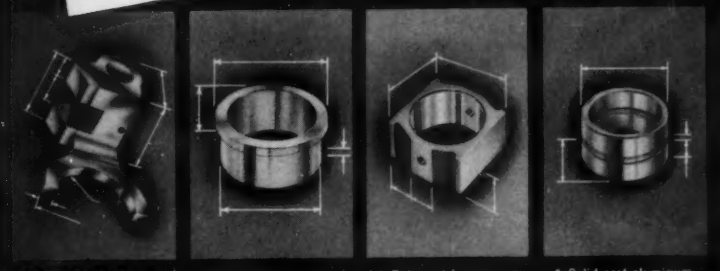

*Clearly evident is the economy in the production of this shifter fork by Bunting Powder Metallurgy. The elimination of practically all machine work effects striking cost reduction.

*This cylinder gland bearing made of Bunting Bearing Aluminum is an example of how to save weight and money on the cost of large, thick-wall bearings and parts.

*This cast bronze cam block, made to unusually close limits with very fine finish, is absolutely round and true to size with cost at a feasible figure.

*Solid cast aluminum gear bearing to replace roller bearing for longer life and lower cost.

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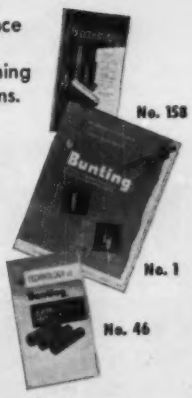
No. 1 Engineering Handbook of Powder Metallurgy—A comprehensive technical treatment of engineering and manufacturing of sintered metals, bearings and parts.

No. 46 Technology of Bunting Bearing Aluminum—A technical treatise on the composition of and machining Bunting Bearing Aluminum Bar Stock.



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Inside the huge swept wing of the Convair 880 . . .
The 120-foot wing span of the Convair 880 permits landings and take offs from almost any airfield that will accommodate four-engine propeller-driven transports, bringing jet-speed travel to most major world cities.
PHOTO COURTESY CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION.
APEX UNIVERSAL JOINTS at work

In producing wing flap actuator systems for the Convair 880, Western Gear Corporation selected Apex universal joints. These joints, designed and built to minimize backlash, help provide the instant, precise operation required by jet airliners.

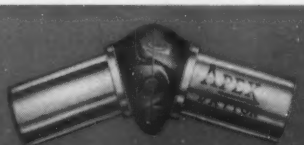
The bearings in each of the Apex universal joints are sealed against abrasive action of sand and dust and have been pre-lubricated for long service life. Male spline, female spline or knurled hub ends are furnished, according to individual application requirements.

The solution to *your* drive-line design problem may be found in the complete line of aircraft and industrial universal joints produced by Apex. And only Apex offers the sealed, lubricant-retaining *covered* universal joint that operates efficiently in fluids, gases, corrosive atmospheres or in extremes of temperatures.

SEE OUR CATALOG IN SWEET'S

or write, on your company letterhead please, for Catalog 28 and Universal Joint Data Sheets.

THE APEX MACHINE & TOOL CO.
1042 South Patterson Blvd.
DAYTON 2, OHIO



Position view of Apex universal joint with lubricant-retaining cover, an exclusive Apex development. Apex coupled joints operate efficiently in wet, dry, corrosive or abrasive atmospheres and at extremes of temperatures.

of probability and distribution, normal distribution, chi-square, binomial and Poisson distributions, and significance tests are discussed. Operating characteristic curves are liberally used to explain difficult statistical concepts.

Nonparametric techniques as well as standard one and two-sample procedures are presented. Tables of factors for one-sided tolerance limits are included.

Encyclopedia of American Associations. *716 pages, 9 by 11½ in., clothbound; published by and available from Gale Research Co., 34th Floor Book Tower, Detroit 26, Mich.; $20.00 per copy.*

This second edition lists 8892 national associations, professional societies, and other nonprofit organizations. Listing includes such information as number of members, description of activities, and special committees or divisions.

Organizations are divided into 18 basic sections. The directory is cross-indexed with multiple entries for each organization.

New Standards

Screw-Thread Standards for Federal Services, Handbook H 28 (1957)—Part II. *119 pages, 7¾ by 10¼ in., paperbound; available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.; $0.75 per copy.*

Issued in November, 1959, this National Bureau of Standards volume is the second of a series of three and amends in part H 28 (1944) and its 1950 supplement. Covered are standards for pipe threads, including dryseal pipe threads; gas cylinder valve outlet and inlet threads; hose coupling, including fire-hose coupling threads; and hose connections for welding and cutting equipment.

ASTM Standards on Metal Powders and Metal Powder Products. *84 pages, 6¼ by 9¼ in., clothbound; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $2.25 per copy.*

Presented in convenient form are ASTM standards relating to metal powders, bearings, structural parts,

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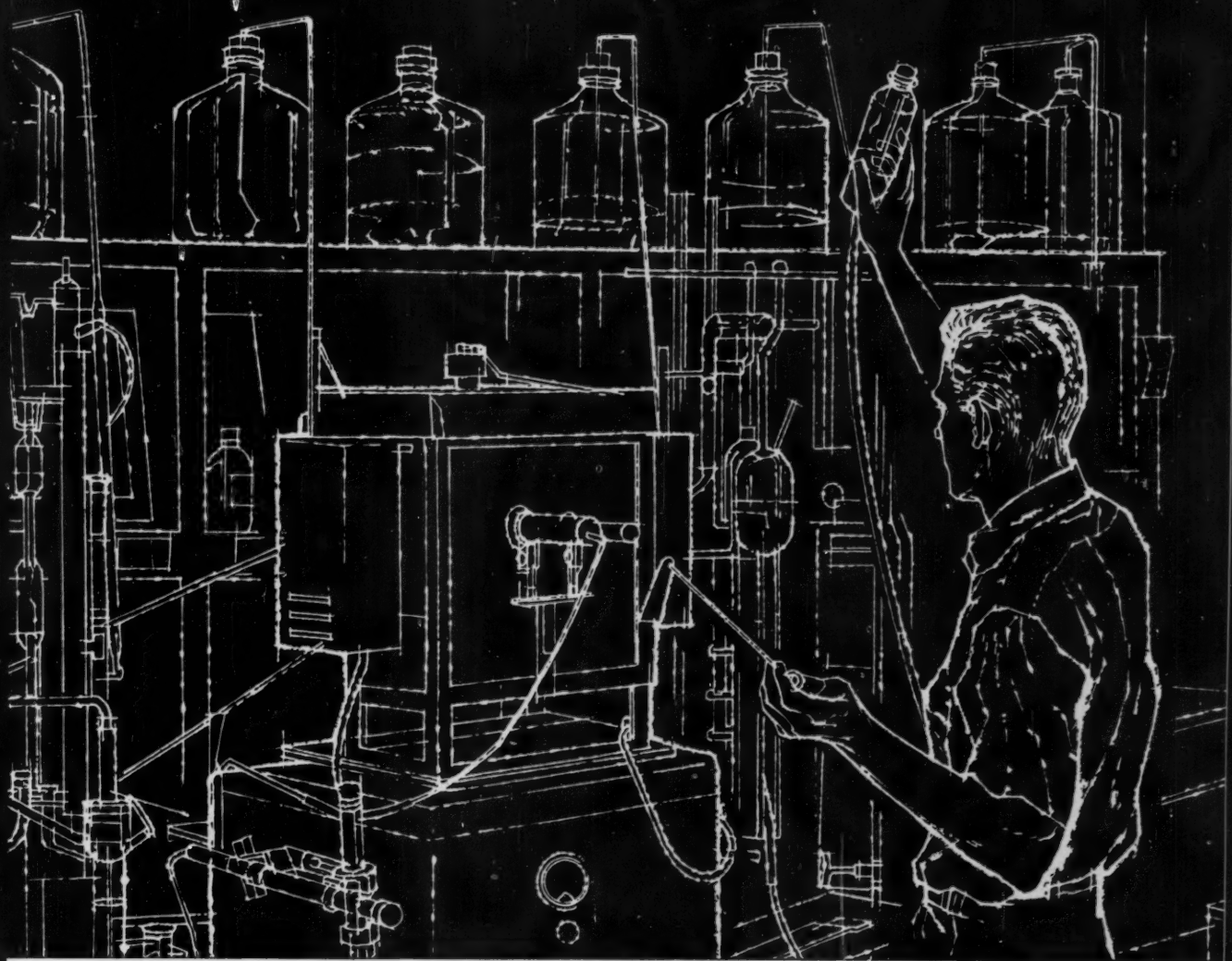
Circle 592 on Page 19→



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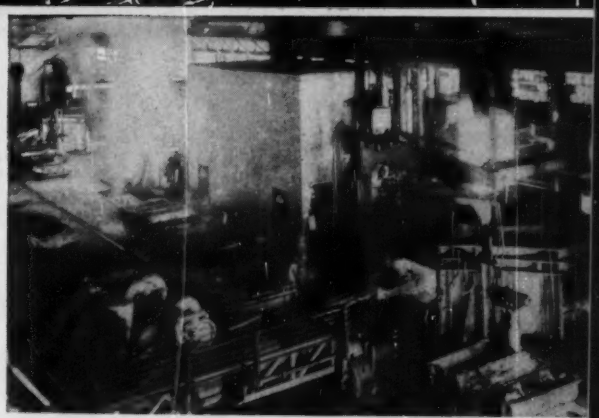

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carbides, heavy metals, and terminology relating to powder metallurgy. In addition to 23 standards, a general description of production processes, mechanical properties, and uses of metal-powder sintered bearings is included.

American Standard, ASA Y32.3-1959, Graphical Symbols for Welding. 100 *pages, 6 by 9 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.;* $3.00 *per copy.*

This standard helps the designer specify complete welding information. Detailed instructions are given for graphically representing every kind of weld.

Association Publications

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics. 465 *pages, 6 by 8¾ in., clothbound; available from Engineering Institutes, University of Texas, Austin, Texas;* $12.50 *per copy.*

Heat transfer, stress analysis and vibration, hydrodynamics and meteorology, hydraulics and hypersonics, special flow problems, instrumentation, and boundary layers were general areas of discussion. Some specific topics included in the 30 papers are secondary flow in straight-open channels, an extended Reynolds analogy, spherical explosions in sea water, tangent flows, and heat transfer by cellular convection in the presence of impressed magnetic fields.

How to Design and Buy Investment Castings. *Edited by Robert H. Herrmann; 176 pages, 6 by 9 in., clothbound; published by and available from Investment Casting Institute, 27 East Monroe St., Chicago 3, Ill.;* $3.95 *per copy.*

This book provides a comprehensive insight into the field of investment castings. Designing of investment castings, determining quality of cast parts, selection of metal, and basic production techniques are general areas of discussion.

Analysis of 1959 Revision of National Electrical Code. *By H. P. Michener, NEMA Staff; 4½ by 7 in., paperbound; available from National Electrical Manu-*

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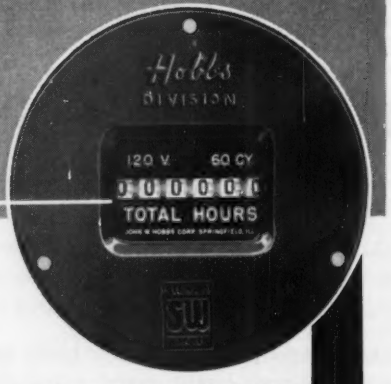
Circle 593 on Page 19

Hobbs INDUSTRIAL HOUR METERS

Basic source for FACTS



UTILIZATION

— tells at a glance in hours and minutes the percentage of available time equipment operates . . . gives the complete picture of the work load requirements, production potential, need for additional equipment. Sets up a sound basis for leased equipment, service contracts, and the sale of used equipment.

MAINTENANCE

— enables the establishment of maintenance schedules on hours of use . . . the organized plan that saves money without cutting quality. Protects equipment and avoids costly interruptions in production schedules.

ALTERNATING CURRENT METERS available in 2½" and 3½" models in Bakelite case conforming to applicable government specifications. DIRECT CURRENT meters also available.

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Industry-approved for wide range of applications. Single circuit, dual circuit; single terminal, double terminal — a complete line.

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Circle 594 on Page 19

Fawick Airflex Clutches on ship unloader pay off quickly thru . . .

power transmission by remote control

Adaptability to remote control is an inherent advantage of FAWICK Airflex Clutches that pays off fast in terms of reduced cost.

A typical example is the push-button ship unloading system at Maple Leaf Milling Company, Ltd., Port Colborne, Ontario, Canada. Here, one man operates the small portable control panel to actuate four FAWICK Airflex Clutches which regulate forward and reverse movements of the drag line scoops. Since modernizing with FAWICK three years ago, the company can point to important reductions in:

- **manpower requirements—down 30%**
- **unloading time—down 20%**
- **power requirements—down 60%**
- **clutch maintenance—none in three seasons**

Through these direct savings the FAWICK units helped pay for the installation in only *one* year!

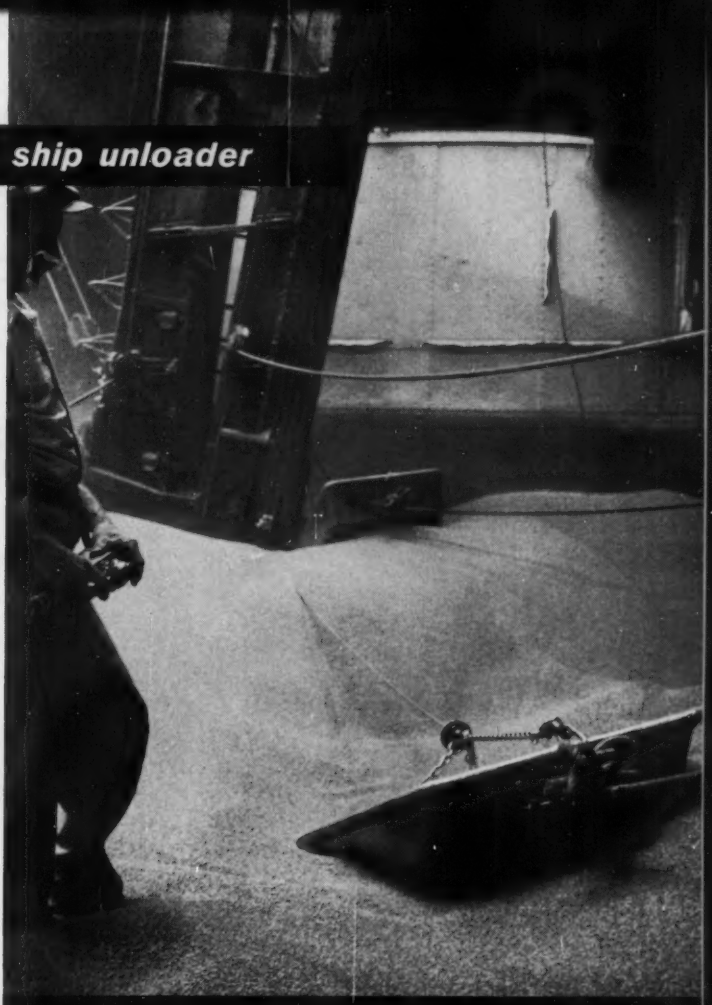
Performance of this type demonstrates FAWICK's adaptability to many and varied power transmission applications . . . and ability to produce benefits that you can count in dollars. Call your nearest FAWICK representative or contact the Home Office for expert assistance in selecting the best clutch for your application.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

FAWICK AIRFLEX

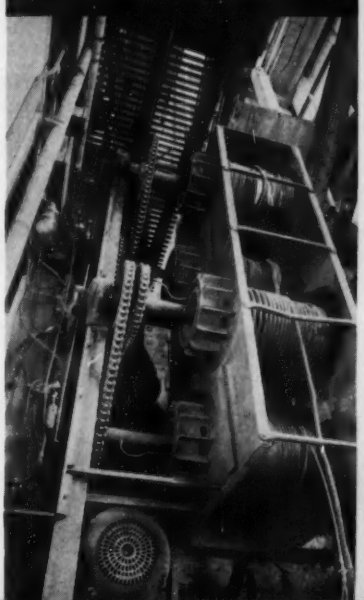
INDUSTRIAL CLUTCHES AND BRAKES

Circle 595 on Page 19



Deep down in the ship's hold, marine power shovel operator is equipped with push-button controls for Fawick Airflex Clutches mounted high above in grain elevator. Instant response of the Fawick units assures precision accuracy in directing movement of multiple scoops which carry grain to intake of lift leg.

Four Fawick Type E Air-Ring Clutches are mounted at "lead line" and "pull-back" drums to control forward and reverse movement of scoops (see above). Designed especially for rugged duty of this type, the clutches have required no maintenance since installation.



Ship unloading system at Maple Leaf Milling Company. Remotely controlled Fawick Airflex Clutches, installed in elevator at right, are directly responsible for $24,000 annual savings in unloading costs.

Flash butt-welding titanium extruded section eliminates 38 lbs. of material...plus machining

When an extruded shape closely approximates the finished cross-section of a circular part, you can save money—particularly where expensive materials are involved. This titanium ring was circular formed and flash butt-welded from the section shown above. Material savings were $262.00 per ring, plus $46.00 on machining.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and complete machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

facturers Association, 155 East 44th St., New York 17, N. Y.; $0.50 per copy.

This analysis shows the nature of each Code revision since the 1956 edition. It is presumed that users will be in possession of the current Code, so no attempt is made to show detail in new requirements.

Research Reports

The Electro-Hydraulic Analogy of Switching Circuits. *By J. M. Case and Ernest C. Fitch Jr., assistant professor, Oklahoma State University; 39 pages, 8½ by 11 in., paper covered, plastic spiral binder; available from Oklahoma State University, Engineering Experiment Station Publications, Stillwater, Okla.; $1.00 per copy.*

A complex electrical control circuit was related to its hydraulic equivalent by means of logic function definitions and electrohydraulic analogies. Final hydraulic circuit was fabricated and tested, and its characteristics were analyzed.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151618. Insulation Study for Airframe Structures. By Gibson Oakes, Aerophysics Development Corp.; 142 pages, 8¼ by 10¾ in., paperbound, stapled; $2.75 per copy.
Properties and characteristics of blanket or fill, molded plastic, and ceramic insulation are discussed. Heating rates of structures with and without insulation are compared, and transient thermal response of airframe structures is evaluated. An optimum insulation thickness is defined.

PB 151789. Spacing of On-Off Controls: Toggle Switches. By J. V. Bradley, Aero Medical Laboratory, and R. A. Wallis, Antioch College; 21 pages, 8¼ by 10¾ in., paperbound, stapled; $0.75 per copy.
Type of switch, spacing, orientation of linear array, and direction of throw were experimental variables. Reach-and-operation time, inadvertent touching of adjacent switches, and inadvertent operation of adjacent switches were performance measures recorded. Data are compared with push-button experimental results.

PB 151909. The Development of Oscillatory Rolling-Contact Bearings for Airframe Applications in the Temperature Range 300 F to 600 F. By W. A. Glaeser, C. M. Allen, D. R. Grieser, and H. A. Van Dyke, all of Battelle Memorial Institute; 104 pages, 8 by 11 in., paperbound, stapled; $2.50 per copy.
More than 1000 commercially available high-temperature roller bearings were evaluated. Three bearing materials, two bearing designs, two oscillations amplitudes, and a number of high-temperature greases were tested under oscillating conditions. Load-life charts with 95 per cent confidence limits were established from statistical analyses of data.

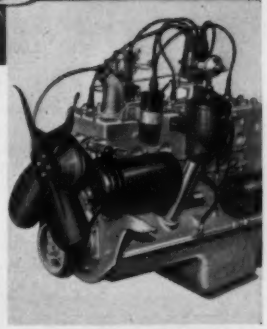
PB 161031. "No Backlash" Universal Joint. By R. E. Stokley, Borg-Warner Corp.; 23 pages, 8¼ by 11¾ in., paperbound, stapled; $0.75 per copy.
Development of preloaded, tapered roller bearings led to construction of a universal joint with no backlash. New joint is interchangeable with other universal joints. Report contains photos, design drawings, and test specifications.

MORE WORKING MUSCLE

IN THE INDUSTRIAL Jeep® L-4 ENGINE

The 'Jeep' L-4 was designed to give you the winning combination you need: the smoothness of a six, with the economy of a four. This rugged engine delivers 20-45 continuous duty horsepower. Coast-to-coast and world-wide distribution of parts. Reasonably priced. Pilot models available.

KEYPOINT ENGINEERING MAKES THE DIFFERENCE. The parts that work the hardest are built the strongest. Every 'Jeep' Industrial Engine is built this way, to insure a long, rugged life. Among the L-4 Keypoint features are Positive Valve Rotators, Hard-chrome rings, Stellite or Eatonite valves, positive crankcase ventilation and many more . . . at no extra cost.



THE 'JEEP' 6-CYLINDER ENGINE
Big brother to the L-4 is the powerful 'Jeep'-6, a heavy duty engine that delivers up to 65 continuous duty hp. High torque in low speed ranges, for extra muscle!

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Manufacturers of 'Jeep' 4 and 6 Cylinder Industrial Engines

Circle 597 on Page 19

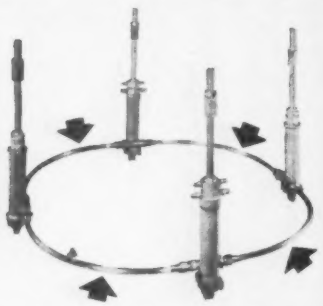
S. S. White

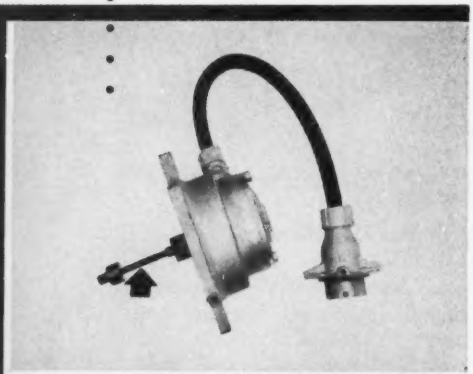
DRIVE AND CONTROL IDEAS FOR ENGINEERS

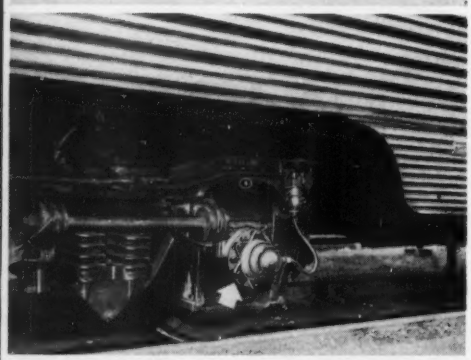
Tips on better designing with flexible shafts

REMOTE CONTROL

Reliable synchronization at high temperature is made possible by S. S. White flexible shafts on this actuator system for jet afterburner nozzles. The job assigned the shafts was to synchronize the system to permit multipoint installation and smooth, even application of power . . . at ambient temperatures up to 650F! To see how flexible shafts simplify design, picture doing this with solid shafts, gearing, universals, and other paraphernalia, around a 360° bend . . . and then imagine installing it!







POWER DRIVE

Running cool at 45,000 rpm! The S. S. White flexible shaft on this grinder-miller permits the use of carbide and diamond tools at speeds that were previously unknown to hand tools. The flexible shaft drives the handpiece from a ¼-hp motor suspended over the table at speeds up 45,000 rpm, without overheating and without vibration. A good point for designers to note is that in many cases, the higher the speed of a flexible shaft, the better the performance.

COUPLING

Alignment and vibration problems are solved by an S. S. White flexible shaft on this railroad brake controller. The device detects wheel slippage during braking, by means of rotary switches on each axle that detect changes in relative movement between pairs of wheels on the truck. If damaging slip occurs, the device releases brake pressure until slippage stops. A flexible shaft is fitted to the axle and drives the rotor in the switch, eliminating alignment problems and preventing excessive axle vibration from reaching the sensitive device.

S. S. White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION (Dept. 4)
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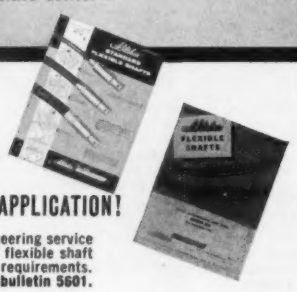


Standard S. S. White flexible shafts are available "off the shelf," making many savings possible. **Write for bulletin 5801.**

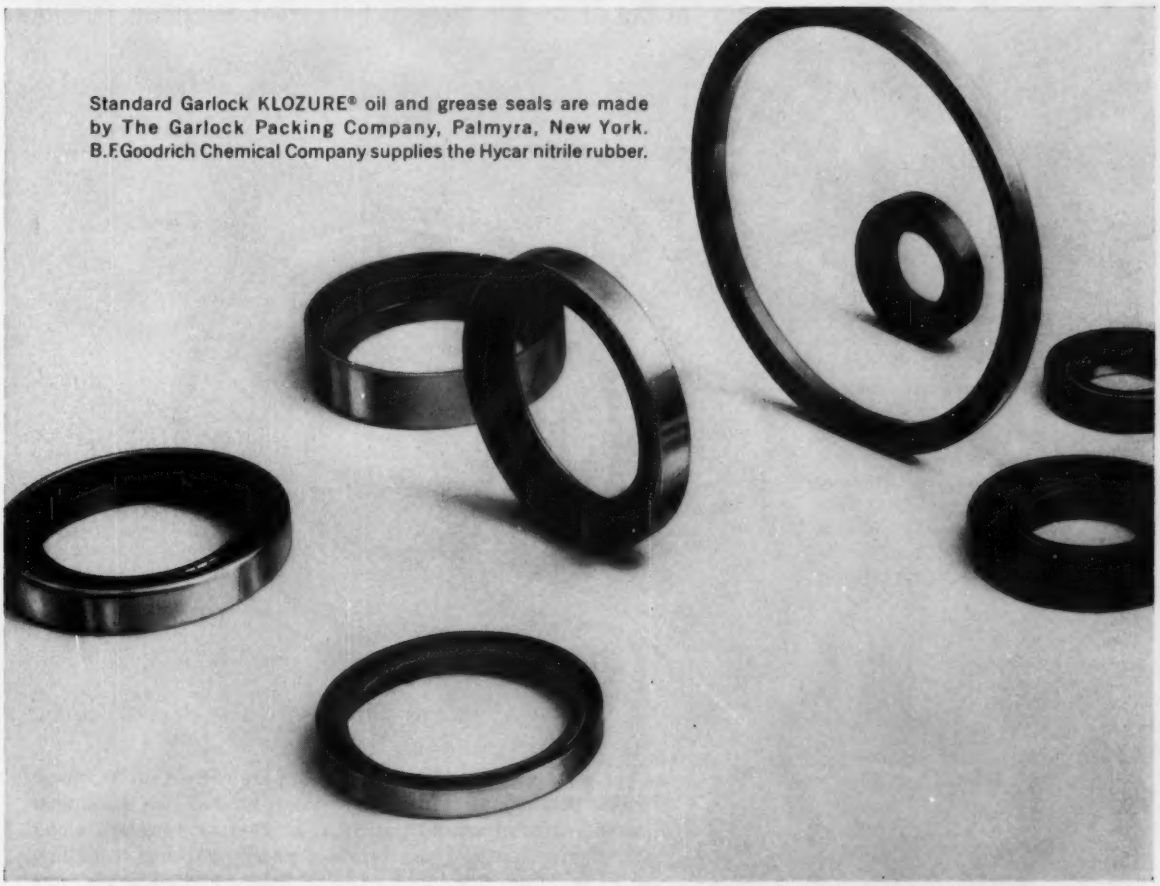
USEFUL DATA ON SELECTION and APPLICATION!

S. S. White also offers engineering service and comprehensive selection of flexible shaft sizes and types to meet special requirements. **Write for bulletin 5601.**

1056

News about

B.F.Goodrich Chemical *raw materials*



Standard Garlock KLOZURE® oil and grease seals are made by The Garlock Packing Company, Palmyra, New York. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.

Here's why one manufacturer selects Hycar to make efficient, durable seals

By using the advantages of Hycar nitrile rubber in its standard compound for making oil and grease seals, The Garlock Packing Company provides sealing elements that are oil- and grease-resistant. In addition, Hycar helps produce homogeneous, non-porous and grainless seals that are impervious to water, mild acids and alkalies.

Further, this manufacturer likes the tough, durable and resilient qualities of Hycar. Shaft seals are abrasion-resistant, yet non-abrasive and free-running. They withstand operating temperatures from –40° F to 250° F constant, 300° intermittent.

Hycar is a versatile material you can use in many ways. For complete information, write Dept. FO-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar

Rubber and Latex

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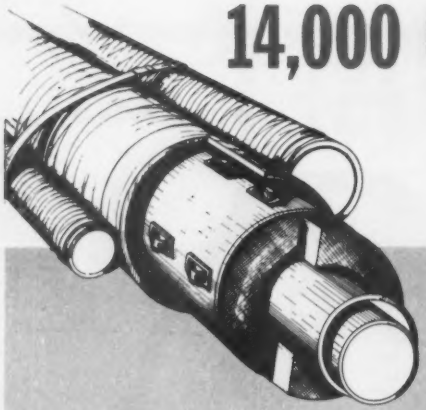
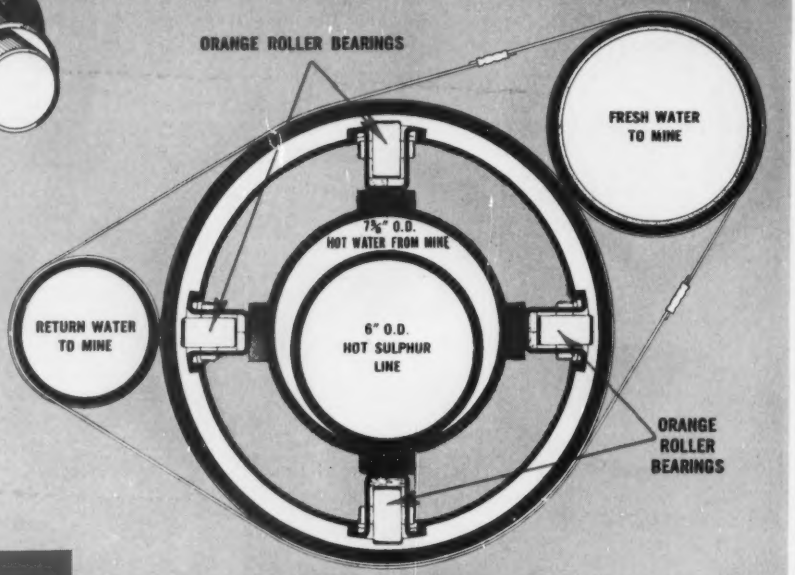
B.F.Goodrich GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

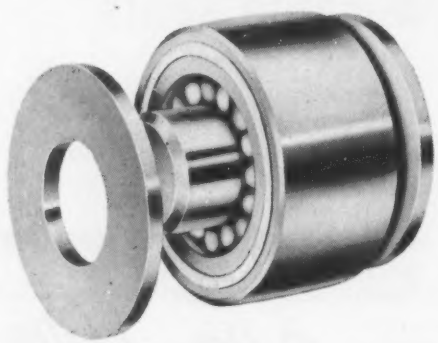
14,000 ORANGE ROLLER BEARINGS

installed in unique 7-mile Hot Sulphur Pipeline at the Grand Isle Mine of FREEPORT SULPHUR COMPANY



This ingenious pipeline, buried five feet below gulf bottom under 50 feet of water, can transport up to 4,500 tons of sulphur daily from the mining plant in the Gulf of Mexico to the loading wharf at Grand Isle, Louisiana. This pipeline, at the world's first offshore sulphur mine, consists of a 14-inch OD protective casing, a 7⅜" hot water jacket line and a 6" OD sulphur line.


ORANGE ROLLER BEARINGS
FRESH WATER TO MINE
7⅜" O.D. HOT WATER FROM MINE
RETURN WATER TO MINE
6" O.D. HOT SULPHUR LINE
ORANGE ROLLER BEARINGS



The weight of the 6" and 7⅜" pipes are carried on 8 Orange roller bearings at each support point, located two in tandem at 90° circumferential positions, at 19½ foot centers along the 7-mile route. These bearings permit pushing or pulling the inner lines through the 14-inch casing and allow very low friction.

The roller bearings, designed and engineered by Orange engineers, consist of 1½" OD outer races with full complements of precision rollers mounted on pins which are inserted in heavy steel cups. The bearings are pre-lubricated and sealed by the pressure of end plates against seals imbedded in the sides of the outer races. The design and construction of the bearing assemblies were based on precise calculations to meet the unusual conditions of heat, loading stresses and permanent lubrication requirements.

Orange engineers and field representatives invite discussion of your bearing design problems, without obligation. The most efficient solution will be furnished from the extensive line of Orange Roller Bearings—or by special adaptations. Write for new 44-page Engineering Reference Manual covering complete line of Orange Roller Bearings.

ORANGE
ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
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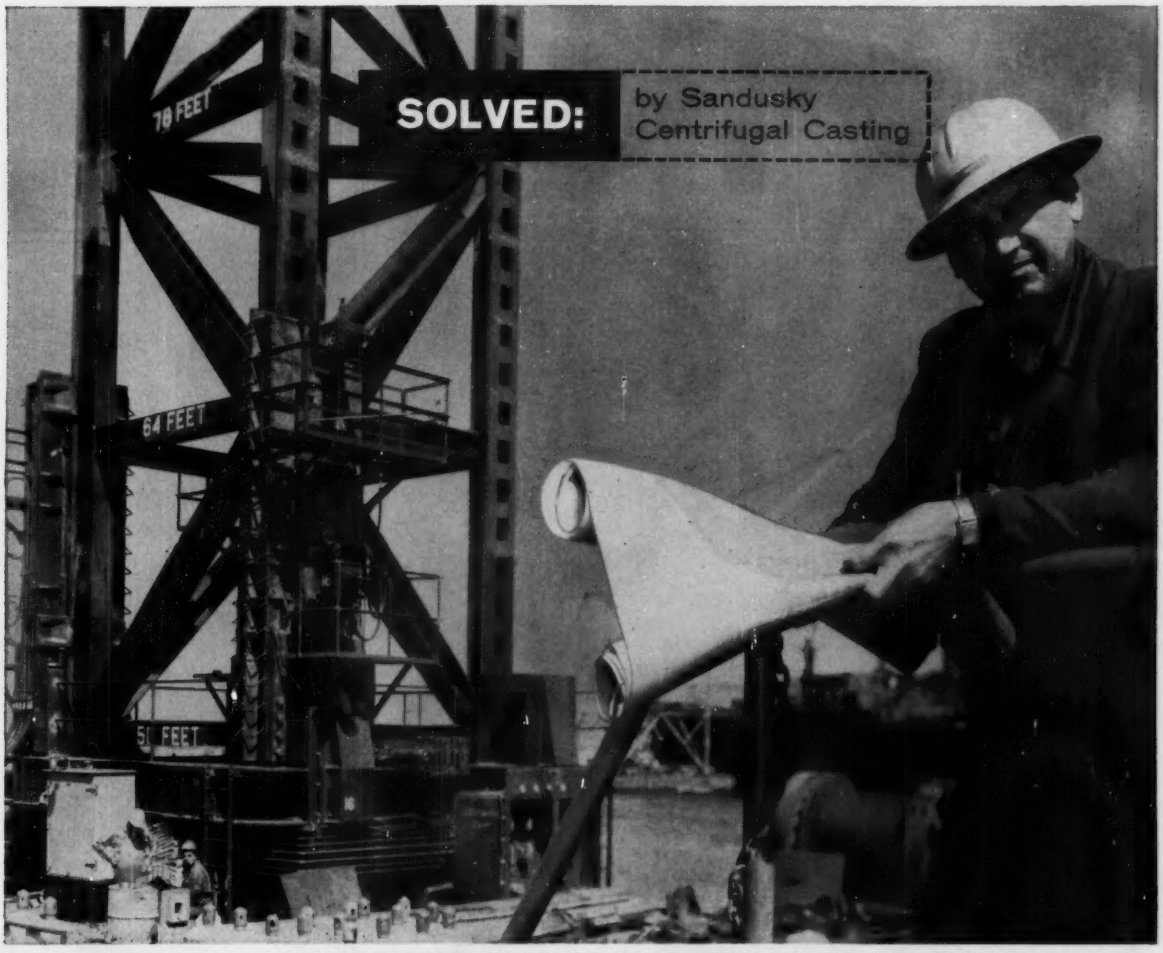


One of four 274 ft. high towers aboard the *George F. Ferris* showing method of installing hydraulic jacks built by Yuba Manufacturing Division, Yuba Consolidated Industries, Benicia, Calif. George Bauer, of Delong Corp., New York, is shown supervising construction while platform is being completed at Yuba's Richmond, Calif., plant.

YUBA gets quality-cost-delivery advantages by specifying 16 Sandusky cylinders

Sixteen 500-ton hydraulic jacks built by Yuba, for which Sandusky supplied the main cylindrical bodies, enable the new pipe-laying barge, *George F. Ferris*, to operate in waters 200 ft. deep!

This 5400-ton barge is equipped with four structural steel towers 274 ft. high. Four jacks on each of the towers provide the power to lower these steel "legs" to the ocean floor, raise the barge above the surface of the water, or retract the towers to render the barge navigable. The steel jack cylinders are Sandusky Centrifugal Castings, made to the requirements of ASME Code-approved SA-217, Section VIII, Unfired Pressure Vessels, to withstand operating pressures of 3000 psi. They were produced in 186" lengths, machined to 24" O.D. with 2" thick walls and sectioned into four pieces 43" long.

Yuba's selection of Sandusky Centrifugal Castings was based largely on three essential factors: QUALITY—meeting the exacting Code requirements . . . COST—saving about half the cost of an alternate method of manufacture . . . and DELIVERY—coming through on a tough time schedule by delivering all 16 cylinders within 21 working days!

When you need cylinders from 7" to 54" in O.D. and up to 33 feet long it will pay you to get in touch with us. Write for our latest booklet, *Your Solution To Cylindrical Problems* containing data on more than 70 ferrous and non-ferrous alloys.

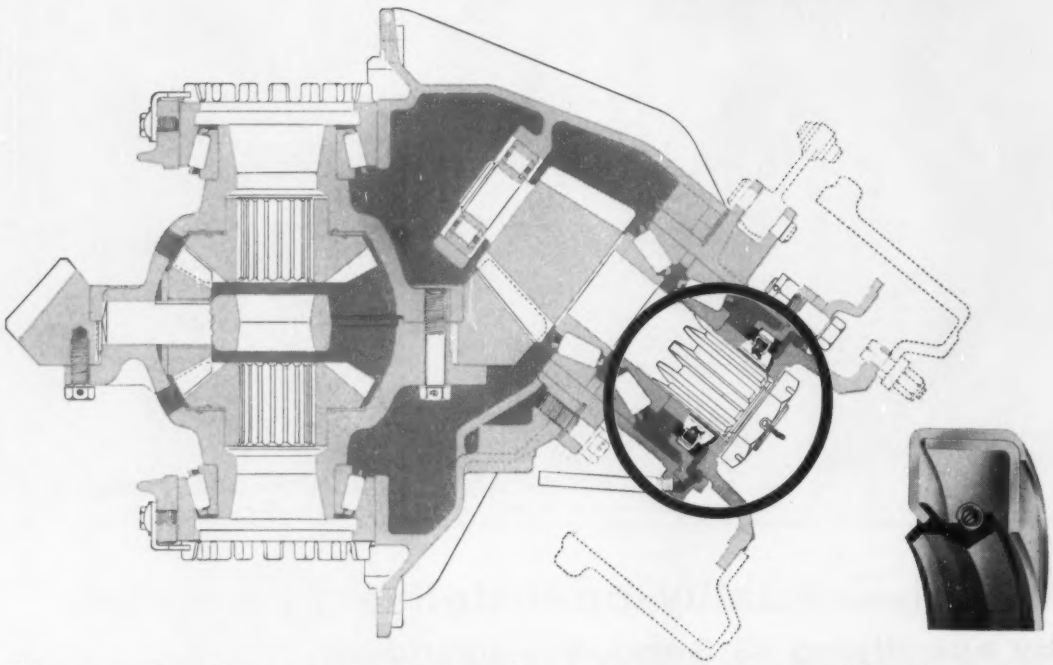
SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.

5302

SANDUSKY, OHIO—Stainless, Carbon, Low-Alloy Steels—Full Range Copper-Base, Nickel-Base Alloys

NATIONAL® OIL SEAL LOGBOOK

for the Mack bus



New design seal ends grooving, eliminates costly flange replacement on bus axle carrier

In early designs of the axle carrier assembly for the new Mack bus, a combination of high temperatures, EP oils hardening the sealing lip and a relatively soft sealing surface on the flange caused grooving. It was then necessary to replace the flange, an expensive procedure.

The problem was solved through application of a new National 410,000 series synthetic rubber oil seal. The special compound of the new-design synthetic rubber sealing lip is unaffected by either high temperature or EP lubricants. To positively insure that grooving will not cause flange replacement, an easily installed wear sleeve with synthetic rubber lining is provided.

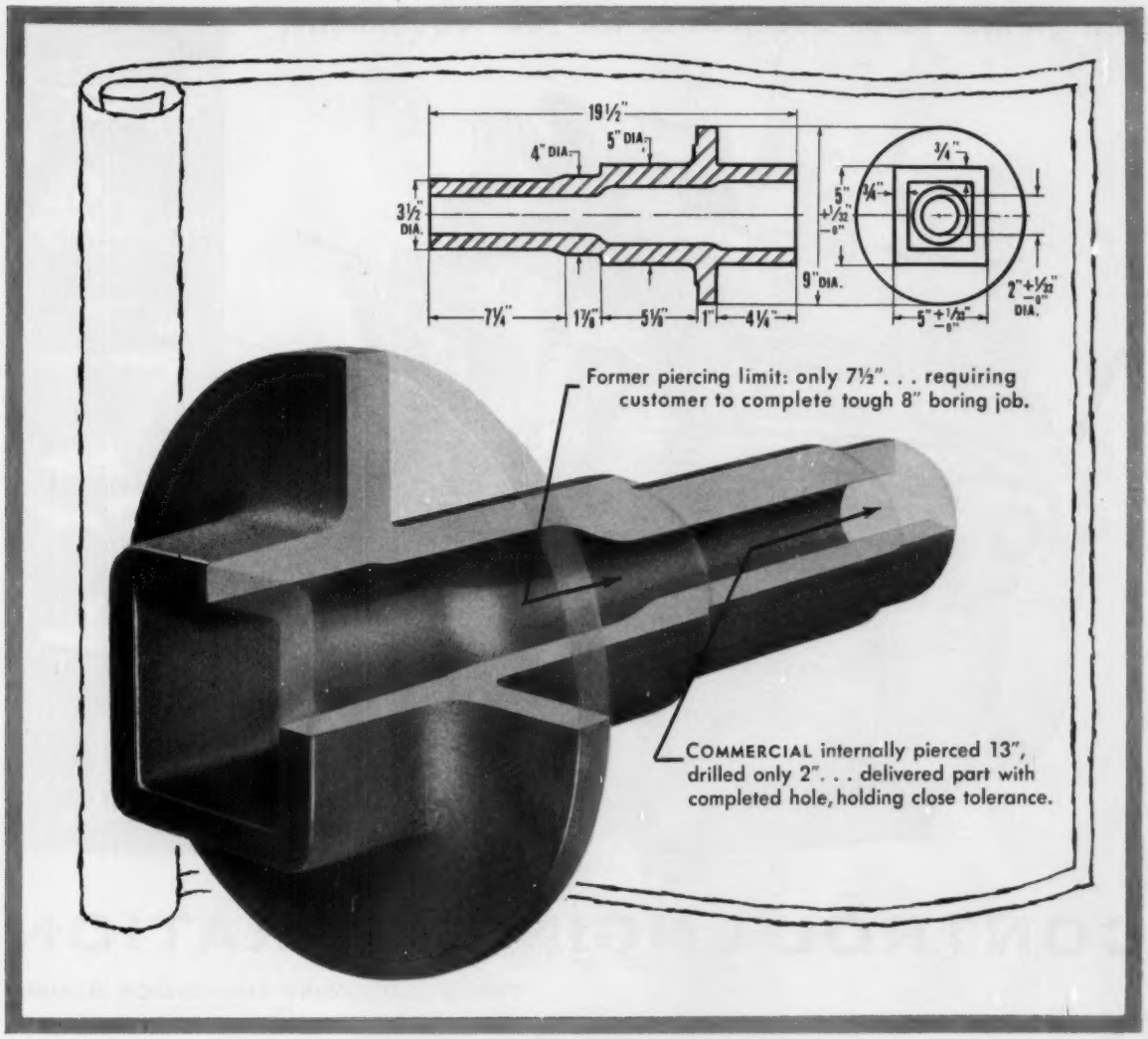
In buses, trucks, tractors and machinery, as well as throughout American motor car manufacture, National seal engineers work with factory designers to provide better, less costly, more efficient lubricant sealing. This experience is yours at no obligation; simply call the National Seal engineer. Look under Oil Seals, in the Yellow Pages.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio; Redwood City and Downey, California

4626

Circle 602 on Page 19



"Task-Forging" Pierces Holes 60% Deeper

Advanced upsetting techniques at COMMERCIAL now permit internal piercing of forgings well beyond the commonly-accepted 7 to 1 length-to-diameter limit.

Good example of new advantages: a 39 lb. rear axle spindle. Formerly the customer had to drill 8" of the 1½" I. D. after forging—a tough job with a close concentricity tolerance.

Now "Task-Forged", the part leaves COMMERCIAL's versatile, integrated plant with completed bore . . .with a substantial savings in metal and machining.

For COMMERCIAL's "Task-Forge" engineering-upsetting-boring team, the improvement was a "1-2-3" routine:

(1) The square end, flange and round end were upset from a 2¾" bar of SAE 8640 steel.

(2) The internal hole of varying I. D. was punched 13". . . over 60% deeper than before!

(3) The remaining 2" of the 1½" I. D. was precision drilled in the same plant.

Like to see what the "Task-Forging" concept can do for you? Just send a sketch or drawing of your part to Dept. S-8.

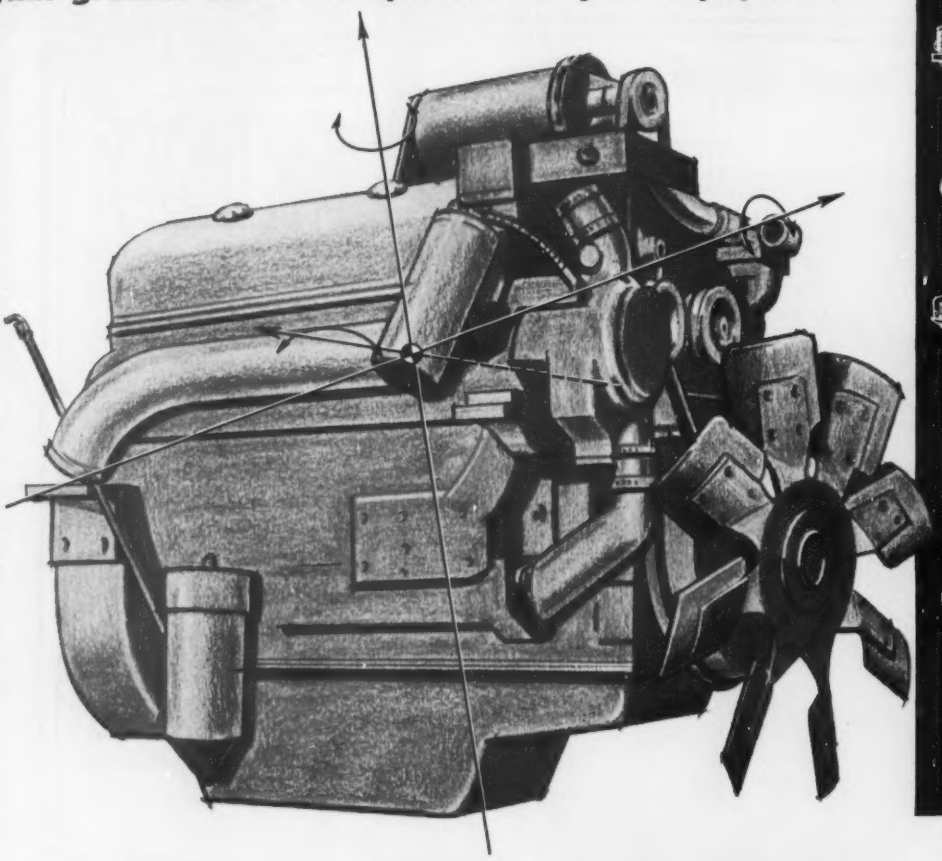
COMMERCIAL SHEARING & STAMPING COMPANY

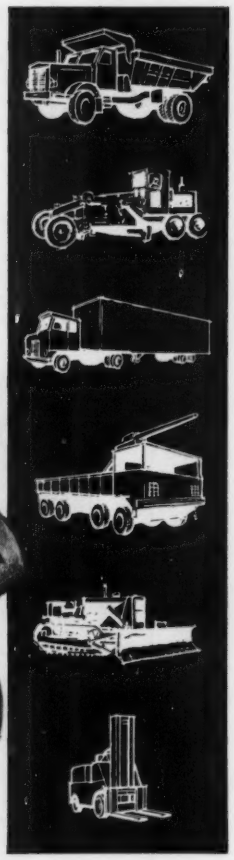
YOUNGSTOWN 1, OHIO

COMMERCIAL shearing & stamping

Circle 603 on Page 19

gain greater sales acceptance for your equipment!





CONTROL ENGINE VIBRATION

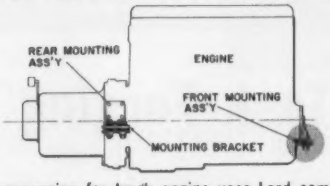
TWO GOOD ENGINE SUSPENSION DESIGNS

Efficient isolation of engine vibration provides an important competitive advantage to manufacturers of modern automotive equipment. LORD-engineered flexible suspensions do the job, assuring smooth, quiet, long-lasting performance that satisfies users.

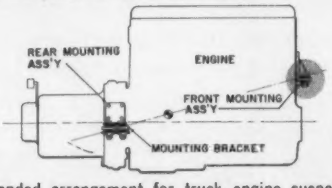
Cushioning the severe torsional firing impulses and unbalance forces of today's high compression, high horsepower engines gives these positive benefits: greater operator comfort . . . less structure-borne noise . . . protection of radiators and components from fatigue failures or malfunction . . . lower stresses on engine and structural members from frame and chassis twist.

LORD engine suspensions of proved design are expertly engineered to meet your requirements for performance and stability. Specially compounded elastomers afford high temperature and oil resistance.

LORD capabilities in vibration/shock/noise control for heavy automotive engines are unmatched. You can utilize them to obtain better performance, greater sales appeal for your engine or vehicle. Contact your nearest Lord Field Engineering Office or the Home Office, Erie, Pa.



Typical suspension for truck engine uses Lord compression-type elastomeric mountings to isolate disturbances and accommodate frame distortion. Center Bonded Mountings feature high unit load capacity and patented rebound protection.



Recommended arrangement for truck engine suspension is decoupled system with front mountings higher than rear. This results in maximum stability and smaller, lighter mountings.

FIELD ENGINEERING OFFICES

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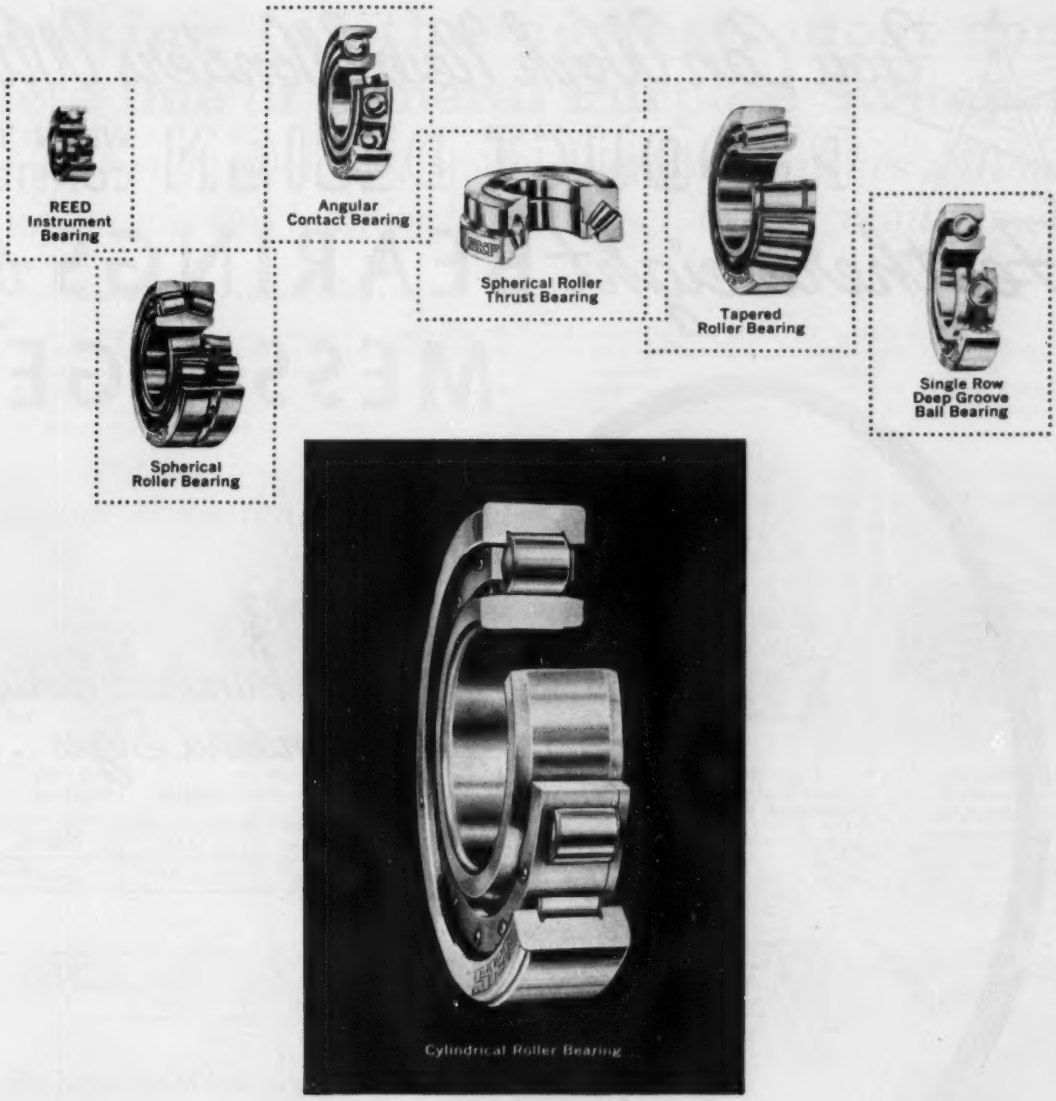
LORD MANUFACTURING COMPANY • ERIE, PA.

LORD®



What's a "special size" in production bearings?

SKF makes so many standard sizes, there's practically no such thing as a "special size" of bearing. They range from tiny instrument bearings right up to four-row tapered roller bearings—and account for almost every possible bore size in-between.

Take SKF's standard cylindrical roller bearing, for example. It's promptly available in 154 sizes of single- and double-row types —for shaft diameters ranging from 1" to 9.5". Every size, in both types, offers high radial capacity in relation to its size and operates at highest speeds because of its very low friction.

So, before you specify a "special size" bearing, call the nearest SKF sales office first. The odds are better than 1,000 to 1 that there's already a standard SKF bearing of exactly the size you need. 6007

Spherical, Cylindrical, Ball, Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE
SKF
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

You Can Work New Wonders With PRODUCT DESIGN WHEN YOU CONSIDER Featherweight BEARINGS by MESSINGER

Two Hundred Forty Standard Sizes...

FROM

I.D.	O.D.	WIDTH
2.00"	2.50"	.250"

TO

I.D.	O.D.	WIDTH
60.00"	62.00"	1.00"

Minimum and Maximum Cross-Sections for Range of Standard Sizes are Shown in Actual Size, at Left.

Despite their extreme light weight and slim section, these "FEATHERWEIGHTS", like all Messinger Bearings, are made to give years of precision performance under surprisingly heavy loads. They provide the widest latitude in bearing application to the design of many types of appliances, machinery and equipment. Write for catalog.

"FEATHERWEIGHTS" are only one of many types of Messinger Bearings which warrant your consideration in the first stages of design—regardless of the size or nature of the project. Consultation available, without obligation.

MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — FEATHERWEIGHT TO HEAVYWEIGHT

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"Smoothing Industry's Pathway for Nearly Half a Century"

Looking for the newest, most complete line of General Purpose Switches?

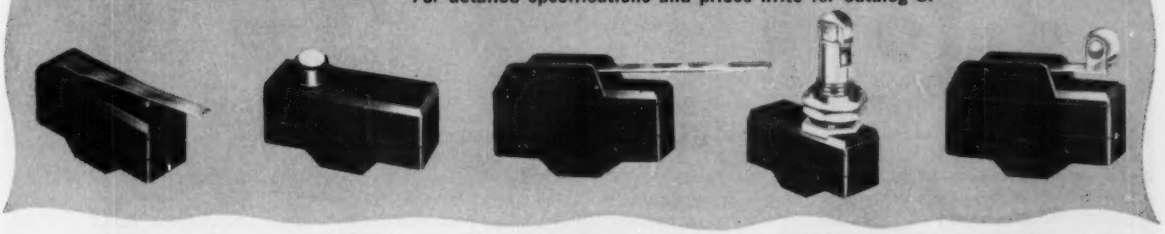
Acro's newly designed model B and F switches will meet your toughest electrical and mechanical requirements

Just check Acro's brand new features!

1. ***NEW!*** Acro's clip-on cover construction, which requires no drilling or pinning, eliminates bakelite dust particles from contaminating the contacts.
2. ***NEW!*** Acro's famous rolling spring principle insures low minimized contact bounce. This gives you high horsepower rating and longer electrical life.
3. ***NEW!*** Up to 21 amp, 2 HP in the F series!
4. ***NEW!*** Moulded-in terminal posts, with blind tap holes, keep out dust and contamination.
5. ***NEW!*** And now Acro offers the most complete line of actuators. Shown are just 10 of the complete series.

model B switches

U.L. Approved 15 AMP 120-240-480 V.A.C. ½ AMP, 120 V.D.C., ¼ AMP, 240 V.D.C.
For detailed specifications and prices write for Catalog B.



BRD2-5L-1S
Leaf Actuator

Operating Characteristics	
Operating force	5 oz. max.
Release force	½ oz. min.
Pretravel	.156 max.
Overtravel	1/32 min.
Movement diff.	.050 max.

BRD2-70-1S
Short Overtravel Plunger

Operating Characteristics	
Operating force	9-13 oz.
Release force	4 oz. min.
Pretravel	.010-.025
Overtravel	1/16 min.
Movement diff.	.003 max.

BRD2-LW8-1S
Overtravel Leaf Actuator (long)

Operating Characteristics	
Operating force	2½ oz. max.
Release force	½ oz. min.
Pretravel	9/32-13/32
Overtravel	.187 min.
Movement diff.	.016-.078

BRD2-24P-1S
Roller Panel Mount

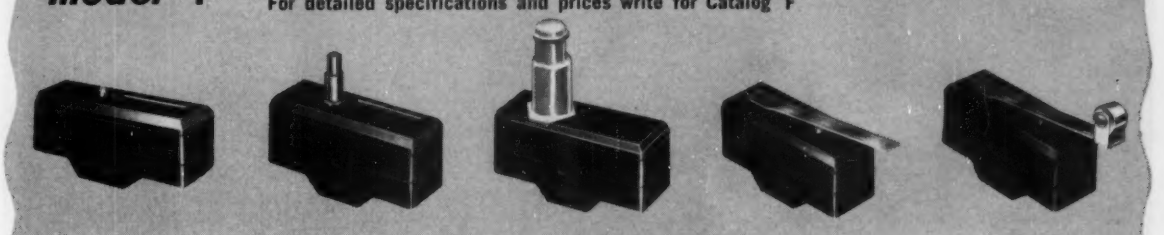
Operating Characteristics	
Operating force	9-13 oz.
Release force	4 oz. min.
Pretravel	.010-.025
Overtravel	.140 min.
Movement diff.	.003 max.

BRD2-LW228-1S
Overtravel Roller Leaf Actuator (short)

Operating Characteristics	
Operating force	6 oz. max.
Release force	1½ oz. min.
Pretravel	.045-.140
Overtravel	.080 min.
Movement diff.	.006-.031

model F

U.L. Approved 21 Amp, 120-240-480 V.A.C., 1 H.P. 120 V.A.C., 2 H.P. 240 V.A.C.
For detailed specifications and prices write for Catalog F



FAD2-1A-1S
Pin Actuator

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	.010 min.
Movement diff.	.0075 max.

FAD2-10-1S
Long Overtravel Plunger

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	1/16 min.
Movement diff.	.0075 max.

FAD2-3P-1S
Large Overtravel Plunger

Operating Characteristics	
Operating force	10-18 oz.
Release force	6 oz. min.
Pretravel	.050 max.
Overtravel	7/32 min.
Movement diff.	.0075 max.

FAD2-5L-1S
Leaf Actuator

Operating Characteristics	
Operating force	9 oz. max.
Release force	1 oz. min.
Pretravel	11/32 max.
Overtravel	1/32 min.
Movement diff.	.065 max.

FAD2-2M-1S
Roller Leaf Actuator

Operating Characteristics	
Operating force	9 oz. max.
Release force	1 oz. min.
Pretravel	11/32 max.
Overtravel	1/32 min.
Movement diff.	.065 max.

for detailed specifications and prices write for catalogs "B" and "F".

Free engineering service. Our engineers will be happy to pit their professional experience against your tough switching problem. Just tell us what it is . . . we'll recommend ways to solve it. No obligation, of course.

RELAYS ACRO SWITCHES

"OUR 21st YEAR"

ACRO DIVISION Robertshaw

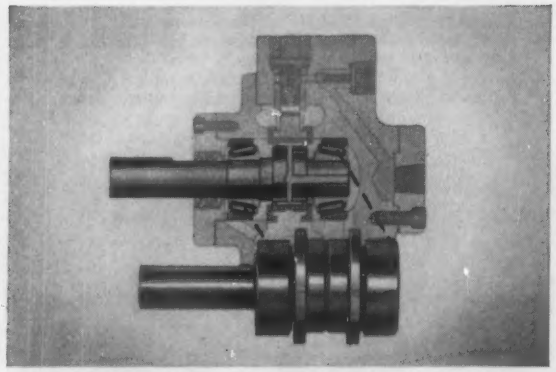
MR. CONTROLS

COLUMBUS 16, OHIO

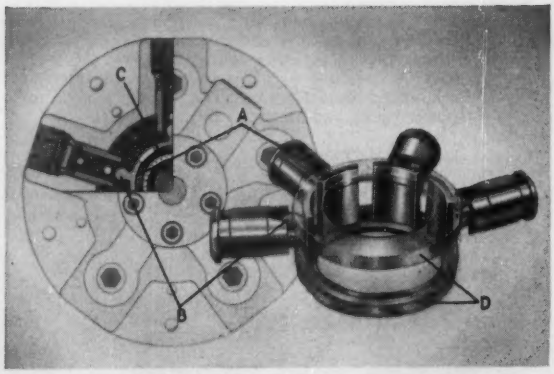
Circle 607 on Page 19

FOR HEAVY-DUTY PERFORMANCE AT PRESSURES TO 5,000 PSI...

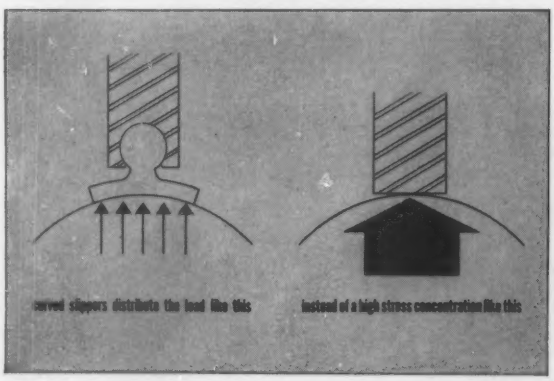
Only one hydraulic pump offers these 4 benefits... AE Hydramite®



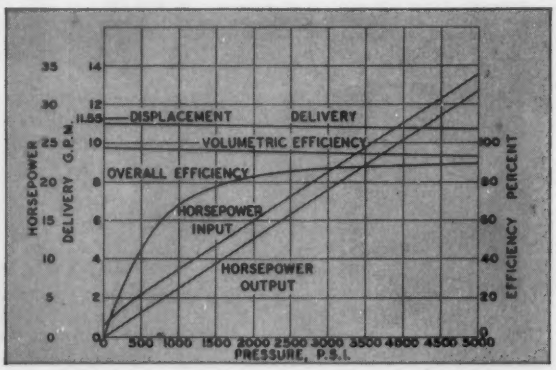
1. Tapered roller bearings. Two high-capacity, heavy-duty tapered roller bearings support the eccentric cam shaft. This means that a Hydramite can take more punishment... handle heavier unbalanced loads... and last longer. The pump casing is ported so that the pumping action of tapered bearings will provide better lubrication.



2. Positive pumping action. No cam follower springs to fail. Each plunger connects to a curved slipper (A) through a knuckle joint (B). In succession, plungers are pushed out by the cam shaft roller bearing (C) and pulled back by return rings (D) which hold each slipper snugly against outer race of the cam bearing.



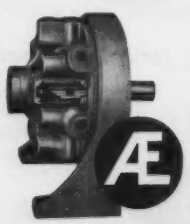
3. Curved Slipper distributes thrust load of its plunger and reduces unit stress to the point where maintenance is never required at what is a critical wear spot in most hydraulic pumps. Also, curved slippers riding on the outer race of the cam shaft roller bearing minimize scrubbing action between these parts.



4. High efficiency. With a Hydramite you get an overall efficiency of 85%. Shown above is typical 10 gpm pump curve. Its flat overall high efficiency has little variation between 1,500 and 5,000 psi. What's more, with a Hydramite you get positive suction. There is no need for supercharging equipment which reduces system efficiency.

To meet your specific requirements, Hydramite pumps can be supplied for constant displacement from 3 to 25 gpm at 5,000 psi and 60 to 100 gpm at 3,000 psi for hydraulic fluids with viscosities of 150 to 300 ssu at 100° F. In special applications they have handled viscosities as low as 40 and as high as 900 ssu at 100° F. Special materials and seals permit handling of missile fuels and special fluids at higher temperatures. Available in flange, foot or face mounted styles.

Write or call American Engineering Company, Dept. P-147, Philadelphia 37, Pa. Phone: CUmberland 9-3800.



See our four-page catalog in Sweet's Product Design File, or write us for reprint (Catalog P-60).

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Hale-Shaw Pumps, Lo-Hed Hoists, AE Marine Deck Auxiliaries, Vibra-Grate, Perfect Spread and Taylor Stokers.

CENTRO-MATIC...

EFFORTLESS,

SAFE LUBRICATION OF OVERHEAD CRANES

Lincoln

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Wanted: Engineers

with an interest in writing

Like to break into an interesting field where you'll make good use of your engineering talents — yet have a chance to develop new skills?

We're looking for several men with engineering experience and a yearning to write or edit. As an editor on MACHINE DESIGN, you would broaden your engineering background in a job that provides stimulating contact with people in many engineering areas.

You don't have to have actual writing or editing job experience, although we expect definite ability in handling the English language. An ME or EE degree plus several years of design-engineering experience would be ideal, but we'll be happy to consider equivalent qualifications. Age: 25 to 35.

If you've worked in a design-engineering specialty area, we'd like to hear about it. We're interested in any job experience or training in:

- Mechanical drives, controls, systems
- Mechanical components, assemblies
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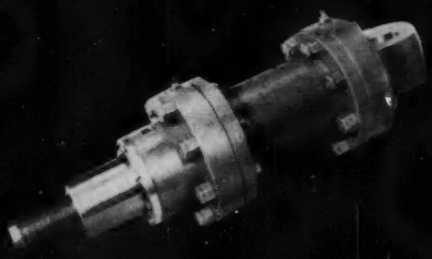
Our headquarters are in Cleveland. There is opportunity for travel to engineering meetings, expositions, and manufacturing companies. Salary will depend on your background and experience.

If you are interested, send a resume of your engineering background, and any evidence you may have of writing ability (we'll return this if you wish) to: Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

MACHINE DESIGN

Here is power cylinder engineering when you need it!



At Anker-Holth we are used to **hurry-up** calls.

We are used to tough problems in pneumatic and hydraulic power cylinder design.

We are used to devoting time and study to a proposal **even if no assurance of an order is there.**

In most cases we can have a factory trained expert in cylinder design at your plant within hours from the time you call us — no matter where you are located or what your needs are.

Anker-Holth service is as close as your telephone. Phone Port Huron, YUkon 5-7181.

Users of standard cylinders: Find out about Anker-Holth's nine complete lines – the most diversified selection anywhere.

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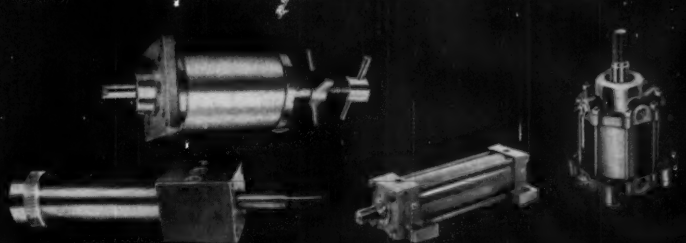
DIVISION, THE McDOWELL-WELLMAN COMPANIES



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The Wellman Engineering Co.
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Circle 611 on Page 19

You can depend on these Quality Fans for

- RATED OPERATION
- LOW NOISE LEVEL
- MINIMUM VIBRATION
- TROUBLE-FREE OPERATION

Highly efficient, quiet, compact units. Ruggedly built, yet light in weight. Easy to install, indoors or outdoors. (Available with all-weather drive covers). Buffalo design assures minimum turbulence, prevents overloading. Variable capacity provides for future increased ventilation needs. Capacity range: 500 to 20,000 CFM. Write for Bulletin 3720-A.

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Professional Viewpoints

. . . symbols for geometric tolerances . . .

Specifying tolerances on drawings by means of symbols instead of notes was proposed in the article "Symbols for Geometric Tolerances" (MACHINE DESIGN, Oct. 15, 1959). Author of the article is Fred L. Spalding, Associate Professor, General Engineering Dept., University of Illinois, Urbana, Ill. The table on Page 302 illustrates recommended symbols.

Reaction of several MACHINE DESIGN readers to Prof. Spalding's article, along with his further comments, are presented here.

To the Editor:

Theoretically, it is desirable to reduce drafting time as much as possible but, practically, the suggestions in this article would cause about the same difficulties as if everybody were expected to learn to read and write shorthand.

From my own experience in different industries and in consulting work, the use of symbols other than those commonly understood always results in more lost time than could possibly be justified by the time saved in the drafting room. Even within the plant where these symbols are used it seems to be impossible to get all toolmakers and machinists to understand the meaning of symbols, and it takes very few trips from the tool room to the design department to more than cancel all possible savings in drafting time.

This condition is accentuated when drawings are sent to subcontractors or vendors because it invariably results in a letter or a telephone call asking for an explanation and, here again, the loss of time on the part of quite a few people does not justify the saving in drafting time.

In the drafting room itself, if all the symbols are not used continuously so that the draftsmen know them by heart, the time used in looking up the appropriate symbol could be more usefully spent in spelling out the requirements.

As stated above, the knowledge of shorthand, whether it be for writing or drawing, is very desirable, but its use as a means of communication usually causes more problems than it solves.

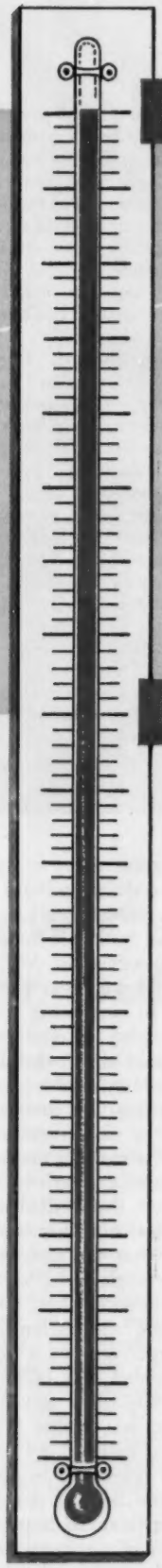
—P. H. WINTER
Chief Engineer
Pass & Seymour Inc.
Syracuse, N. Y.

To the Editor:

Mr. Winter certainly has a point—that any system of shorthand requires constant use in order to maintain familiarity with the characters used. However, the primary use of symbols for geometric tolerances is not the saving of drafting time but the elimination of repetitious notes, thus

Circle 612 on Page 19

Metallurgical Memo from General Electric



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Properties of René 41* . . . the proved General Electric vacuum-induction-melted super alloy . . . demonstrate unique operational reliability.

Designed to meet severely stressed supersonic temperature applications, René 41 has worked wonders for many needs in the space age. High-strength characteristics and ease of workability make it one of the most versatile high-temperature materials available today.

René 41 is available in strip, sheet, bars, wire, and in forgings, plates or billets. It can be readily machined, forged, drawn, spun, welded or brazed.

If your problems center in the high-temperature range, write for all the facts on G-E high-purity vacuum-induction-melted alloys. Feel free to phone for the on-the-job assistance of a G-E engineer. *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Ave., Detroit 32, Michigan.*

*René 41 is a trademark of the General Electric Company

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Very seldom. In most cases, and particularly with spool valves, sticking valve members create overloads, overheating and coil burnout.

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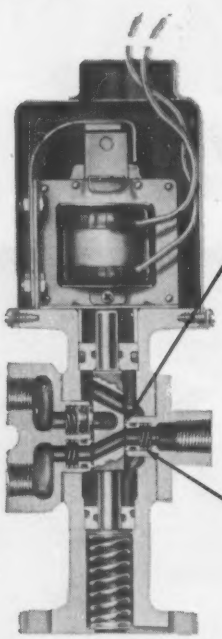
Perhaps a little ridiculous, but the way many plants waste it, you would think it was free. Actually, compressed air not properly controlled can be the most costly power medium you use. We have a study on the dollar cost of air leaks that will blow your hat off.

"AIR VALVES ARE ALL ABOUT THE SAME"
When they are new they all work fine. While all other valves start going down-hill with every operation, the sealing qualities of Barksdale Valves are improved through operation.



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WEAR COMPENSATING FEATURE CONSERVES COSTLY AIR

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providing a drawing that is easier to use.

The use of symbols is not uncommon in drawing practice. Other symbols are used and universally understood, such as finish marks, thread symbols, welding symbols, and piping and wiring diagram symbols. Symbols occupy less space than complete notes and consequently give the drawing a less cluttered appearance. They may be applied in a more uniform manner than notes. Symbols eliminate the tendency to differences in wording of notes, which often result in inaccuracies of both expression and interpretation. Once familiarity with the symbols is gained, a drawing can be read more quickly and accurately.

However, it is evident that before geometric tolerance symbols can be introduced, it is very necessary that the tolerancing principles involved are widely used and understood.

Undoubtedly, there are many drawings made and used today which should, but which do not, have geometric tolerances specified, owing to the difficulty of expressing or interpreting the geometric requirements of designs that have relationships involving these characteristics, and to the extra difficulty of composing notes which would be understandable. Too frequently such specification has been left off the drawing, and complete reliance has been placed on "good workmanship," without defining what that constitutes. Then the problem is whether the shop will interpret "good workmanship" in the same manner as the designer.

If a universally recognized "shop practice standard," defining "good workmanship" could be developed, then, of course, the entire problem would be solved.

—Fred L. Spalding

To the Editor:

I wish to point out that a great many companies engaged in commercial work are doing military work also. In the course of accepting military work, a company is obligated by contractual promises to adhere to military specifications. One specification, MIL-STD 8, defines "Positional and Other Geometrical Tolerancing" in Section 4 of issue 8A. In comparing the two methods of tolerancing and symbol designation the MIL-STD 8 requires flatness to be designated by the symbol for "Twist" in Prof. Spalding's table; it omits any designation for twist. It requires that concentricity be designated as a dot within a circle, and not as shown in the article. MIL-STD 8 also omits many other geometrical and positional tolerance symbols shown in Prof. Spalding's article. Further, the method of calling out these facets of geometrical and positional tolerancing information differs in that the spec requires that a specific dimensioned rectangle ($1\frac{1}{4}$ x $\frac{1}{4}$) be used to contain the symbol, reference letter, and tolerance. The rectangle containing the datum feature symbol is also controlled dimensionally ($\frac{5}{8}$ x $\frac{1}{4}$) and the symbol letter must be preceded and followed by a dash (as suggested in Prof. Spalding's article).

My reason for writing this to you is that I believe it is time that industry and the military got together and standardized on one set of rules. We would then be devoid of controversies in the field of design and drafting practice. It would be a financial impossibility for a company to have two sets of standards, one for the military and one for commercial productivity. I am of the opinion that the controversy of simplified

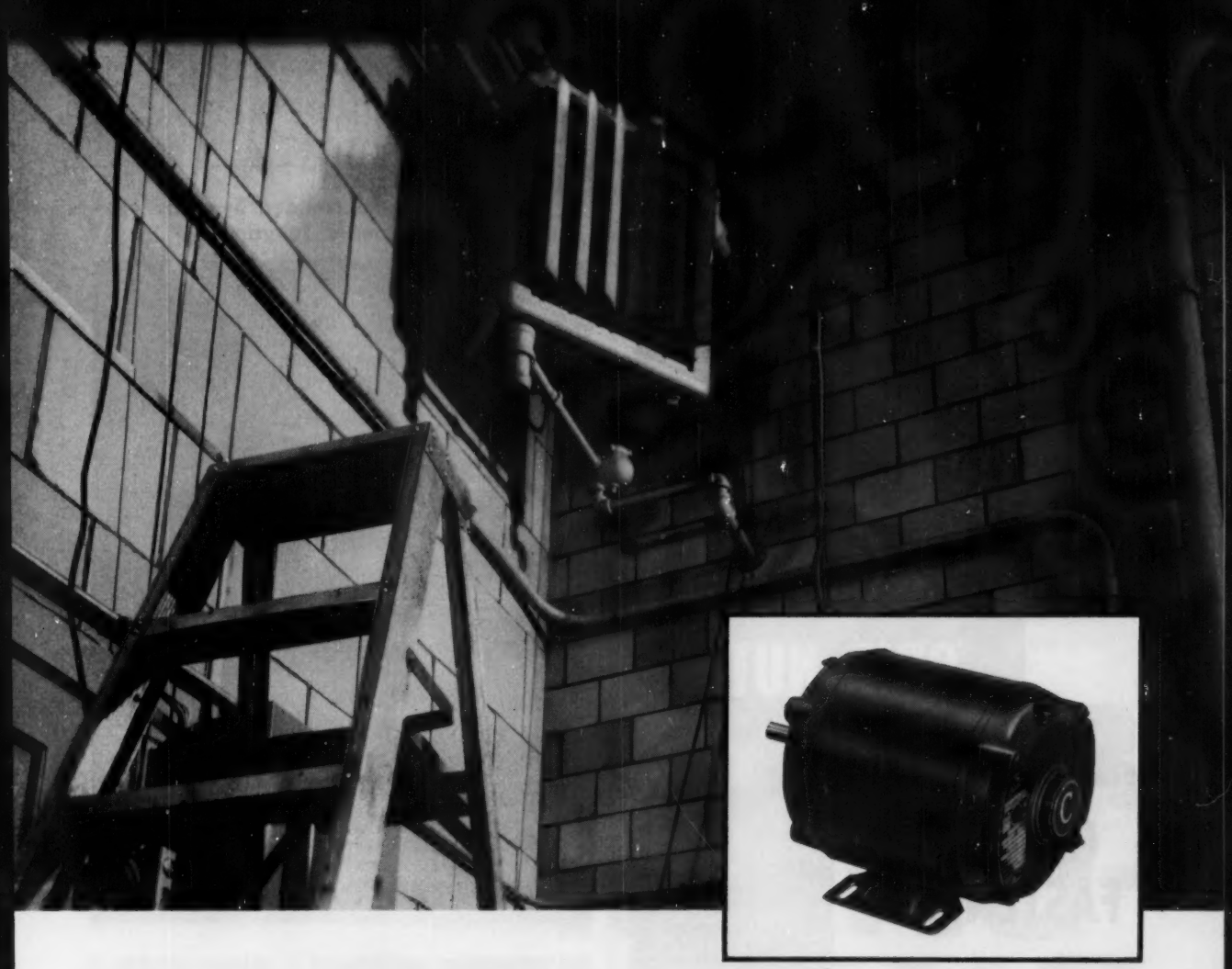

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TABLE 1—Recommended Symbols for Geometric Tolerances

Basic Symbols	
Alignment	⌓
Angularity	∠
Concentricity	◎
Flatness	▱
Parallelism	∥
Perpendicularity or squareness	⊥
Roundness or circularity	○
Straightness	⏜
Symmetry	≡
True position	⌖
True profile or true contour	⌓
Twist	⌇
Qualifying Symbols	
Maximum material condition (MMC)	Ⓜ
Regardless of feature size (RFS)	Ⓢ

drafting practice can be solved by this united effort. I am not saying that simplified drafting is out of the question or not feasible. It can be adopted as standard, however, only by companies doing commercial—not military or government—business.

—F. Martoccia Jr.
Standards Engineer
Electronic Communications Inc.
St. Petersburg, Fla.

To the Editor:

Congratulations on the publication of the excellent article entitled "Symbols for Geometric Tolerances" by Prof. Fred L. Spalding. Prof. Spalding's comprehensive and extremely timely article, advocating the use of these symbols, will undoubtedly do much to arouse interest in this most important subject.

With regard to Table 1, showing recommended symbols for geometric tolerances, however, it is perhaps unfortunate that Prof. Spalding has omitted to separate the sheep from the goats. He lists a total of twelve basic symbols and two qualifying symbols, but does not give any indication in the text as to which of these symbols have been approved by the ABC Conference for use in the English-speaking countries. (Reference should be made to the report of the ABC Conference held in Toronto, October 7-11, 1957.)

It will be found that six symbols only, those for angularity, concentricity, squareness, roundness, symmetry, and true position were approved as shown in

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Table 1. These have also been accepted by ISO Committee TC/10/SC1 in their latest draft, 1959. The ABC Group also accepted one symbol to represent both straightness and flatness, this to be a straight-horizontal line, or alternatively, the symbol shown for straightness in Table 1. ABC Conference also accepted as a symbol for parallelism two lines sloping at approximately 40 degrees, or alternatively, two vertical lines. All the remaining symbols are suggestions only and have, as yet, no approval by National Standards.

—GEORGE NOBLE
Standards Engineer
Dominion Engineering Works Ltd.
Montreal, Canada

To the Editor:

It is very true that companies engaged in military work are obligated to follow military standards. However, MIL-STD-8A was in process of revision at the time the article was written. What form these revisions will take is anybody's guess, but it seems likely that they will, in general, follow the recommendations of the ABC Conference in Toronto in October, 1957, and the ASA standard. The ABC Conference recommended the use of either the straight line or the "eyebrow" as the symbol for both flatness and straightness, and the ASA undoubtedly will show only the "eyebrow" as the symbol for these characteristics, replacing the old sin curve of MIL-STD-8A. This leaves the sin curve out entirely. So far as I know, no generally recognized standard has a symbol for twist, such a geometric control being specified, where required, only in note form. Since twist is merely a special case of flatness, I proposed the use of the sin curve as a symbol for twist for two reasons: To get a symbol for twist recognized, and to maintain a logical interpretation for the symbol where it has already been used, thus eliminating the necessity for changing thousands, perhaps hundreds of thousands, of existing drawings.

As for the symbol for concentricity, the circle around a dot is shown in MIL-STD-8A and will undoubtedly be the same in the new revision. The symbol of two concentric circles is shown in the tentative ISO standard and some company standards. While my opinion is that the two concentric circles make for greater legibility on the drawing, I think either, or both, could be used without confusion.

Regardless of the actual symbols used, I agree with Mr. Martoccia that it is time industry and military get together on one set of standard symbols.

In reply to Mr. Noble's comments, so far as I know, no recognized industrial, national, or international standardizing body has yet approved and published any system of symbols for the specification of geometric tolerances.

—FRED L. SPALDING

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"We need to quit worrying so much whether personnel is spending too much time congregating at the water cooler and spend more time making certain supervisors don't assign their personnel to auxiliary functions that should be performed by other departments." —J. GRANT MACDONNELL, *treasurer, Norair Div., Northrop Aircraft Corp., Beverly Hills, Calif.*

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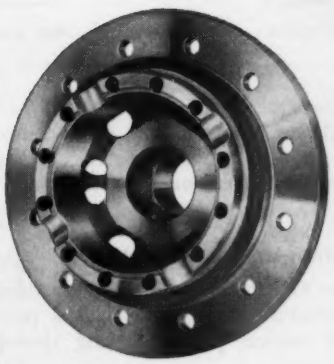

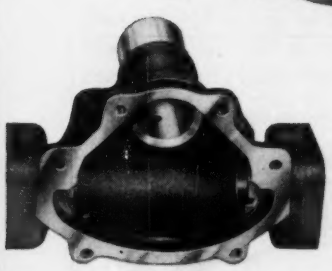

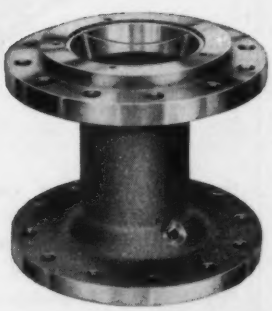

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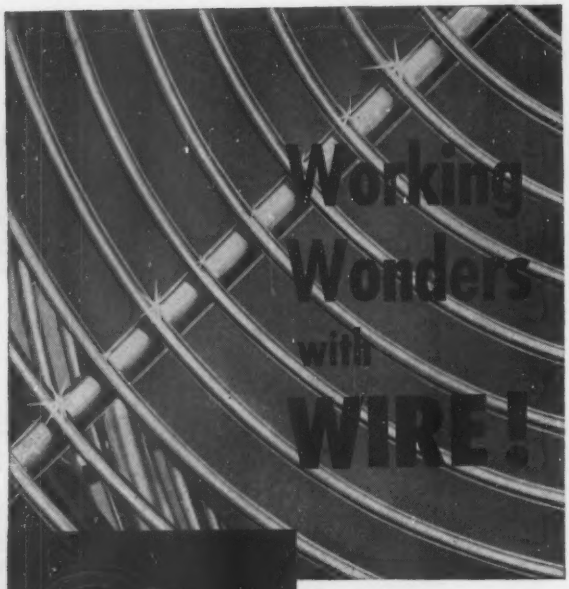

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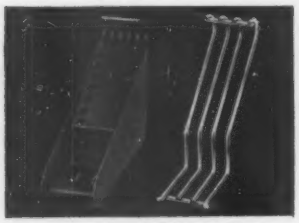

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Patents

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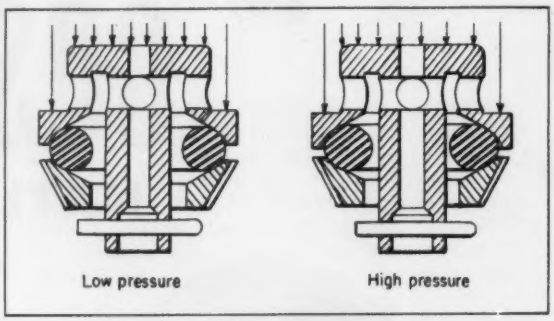
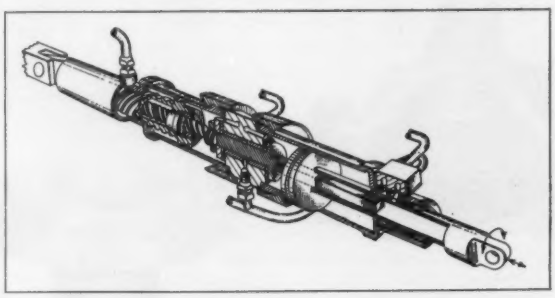


area between the O-ring and the stem. Flow through the central passage in the stem is not controlled. *Patent 2,914,084 assigned to Speakman Co., Wilmington, Del., by Edward S. McLean and James Fraser.*

Combination-Motion Actuator

Both linear and rotary motions are provided by a dual-output actuator design. One piston produces linear motion. A second piston, driving through a screw



thread arrangement, converts linear into rotary motion. The two pistons are independently controlled and can be operated simultaneously or independently. *Patent 2,918,799 assigned to General Motors Corp., by Howard M. Geyer.*

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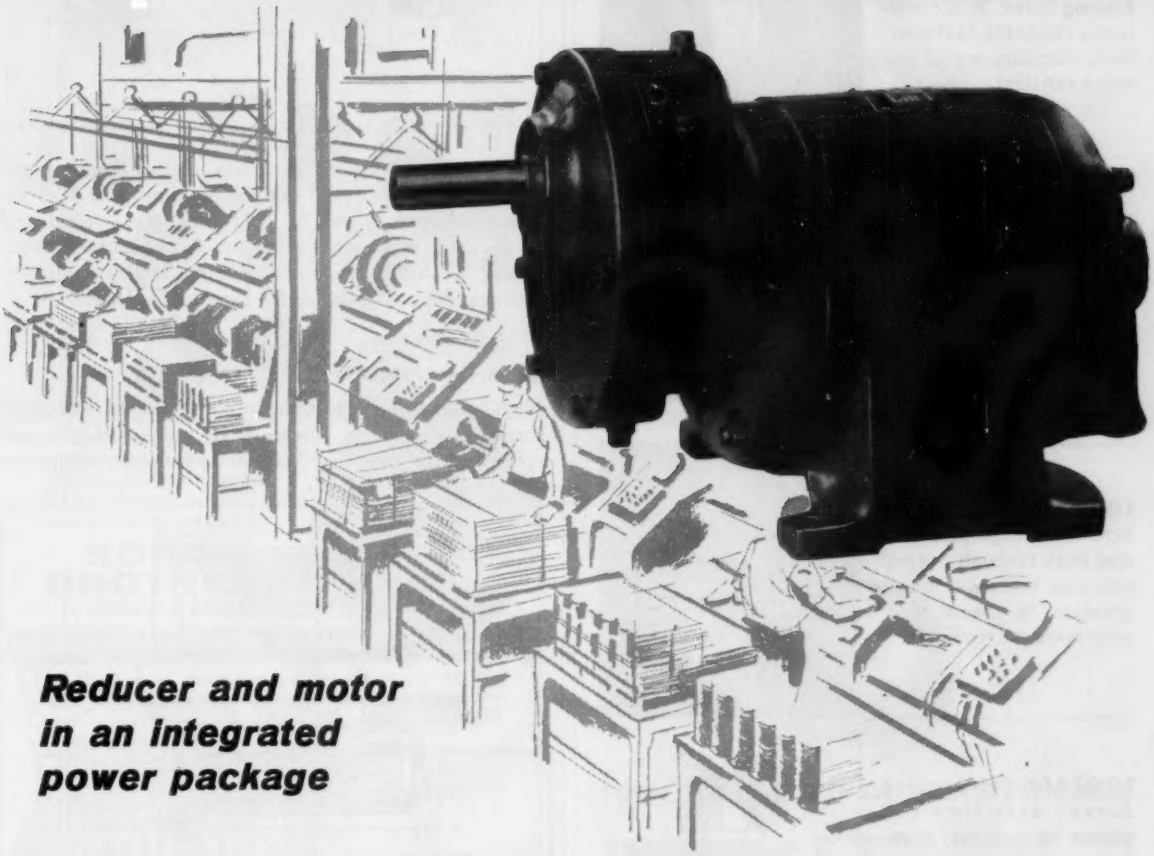

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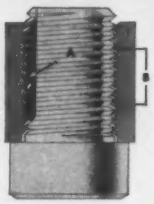

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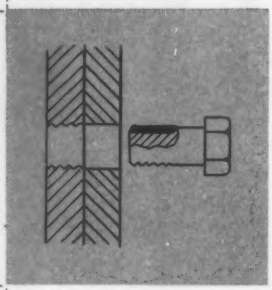

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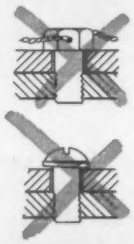

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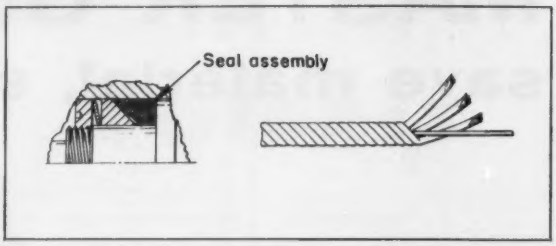

sufficient flexibility to maintain sealing engagement. The gland is produced by die forming a coil of asbestos-wrapped wires. In operation, the conical end of the seal is spring loaded to compensate for wear. *Patent* 2,918,339 *assigned to Cleveland Pneumatic Industries, Inc., Cleveland, by Donald G. Hagadone.*

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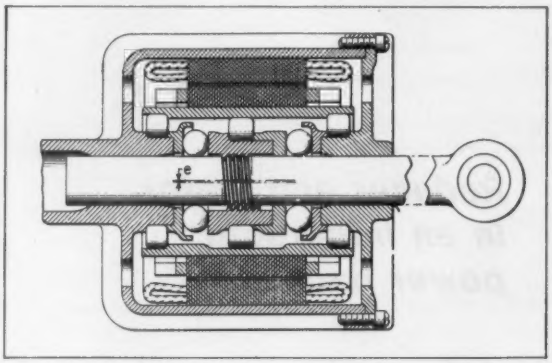

nut, producing a planetary-type motion. The threads of the nut roll against screw threads on the output rod. Amount of speed reduction is determined by nut eccentricity, diameters of nut and screw, and thread pitch. *Patent* 2,918,827 *assigned to General Electric Co., by Arthur E. Brown.*

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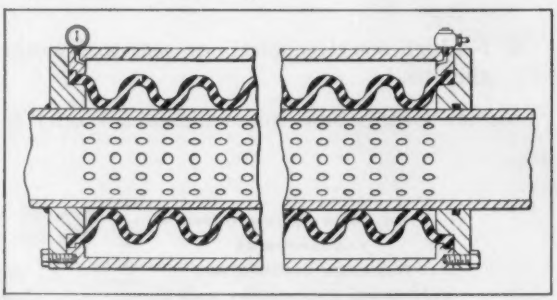

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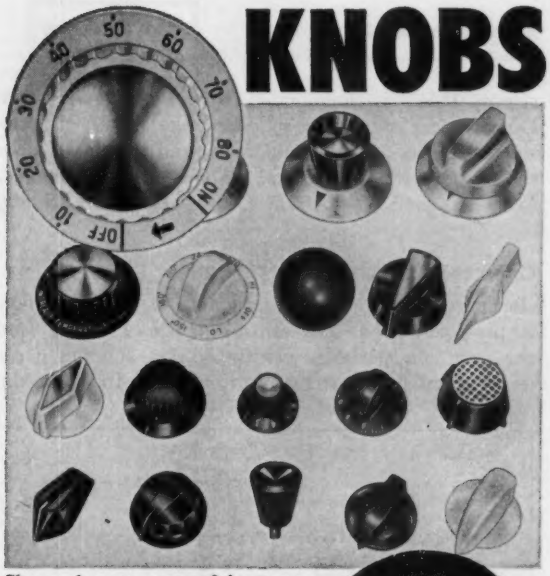

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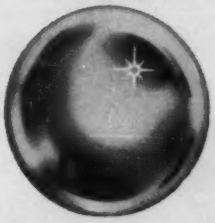

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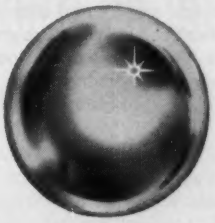

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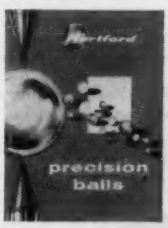

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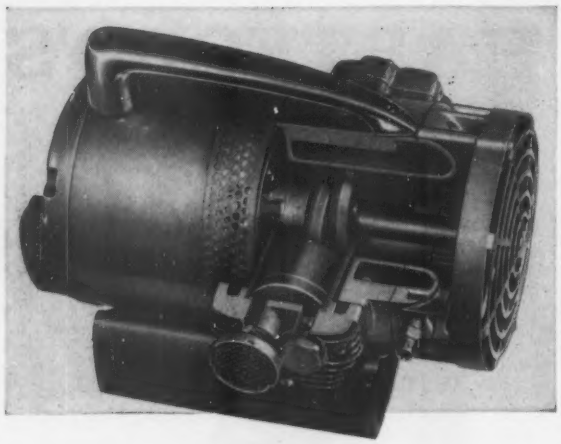
Circle 624 on Page 19



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...CONTINUOUSLY!

no messy, oil-laden discharge vapors

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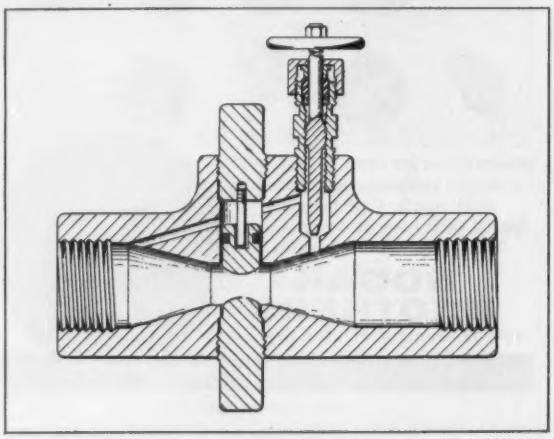
Oil-less
VACUUM PUMPS
BELL & GOSSETT COMPANY
Dept. GB-67, Morton Grove, Illinois

Circle 625 on Page 19

sleeve which is surrounded by air under pressure. During dips in pressure following the surges, air pressure developed in the chamber around the sleeve forces the fluid back into the line. *Patent* 2,918,090 *assigned to Westinghouse Air Brake Co., by DeWitt L. Shelly.*

Constant-Volume Venturi

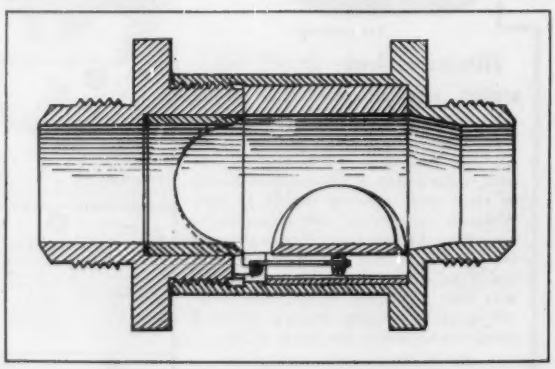
Constant outlet volume independent of inlet conditions is provided by a flow-control device. Pressure from the upstream side of a venturi section actuates a piston to regulate the venturi throat area. Initial setting



is determined by an adjustable bypass valve. Thereafter, upstream pressure fluctuations vary venturi opening to produce constant volume at valve outlet. *Patent* 2,918,933 *assigned to Oil Center Tool Co., Houston, by Boyd D. Boitnott.*

Low-Restriction Check Valve

Minimum resistance to flow through a valve in the open position results from its cylindrical shape. The operating pivot of the valve is outside the internal



diameter of the conduit. The cylindrical valve swings shut against a mating seat to prevent flow in the opposite direction. *Patent* 2,913,001, *assigned to Flight Refueling Inc., Baltimore, by John F. Maslow and Richard J. Zeitler.*

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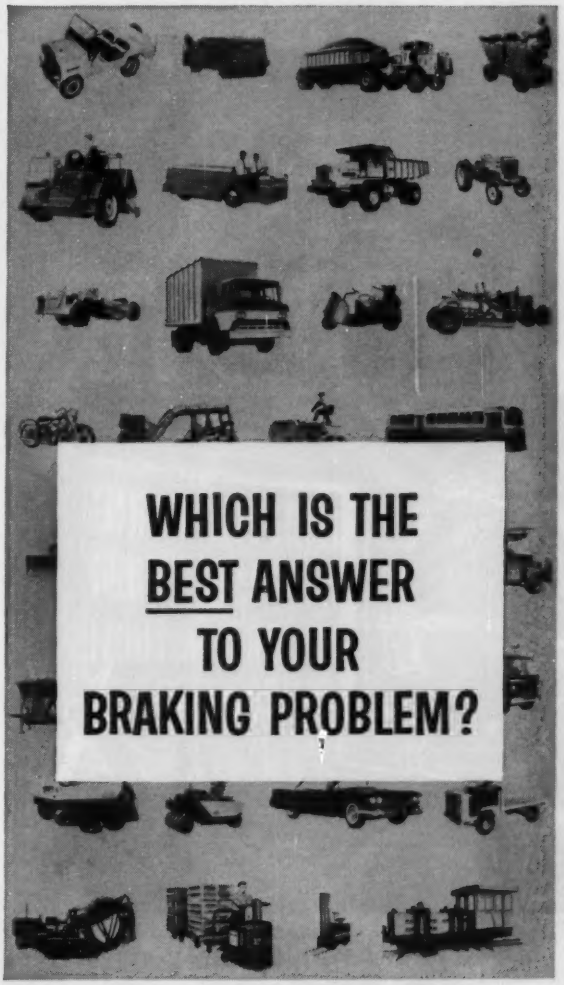

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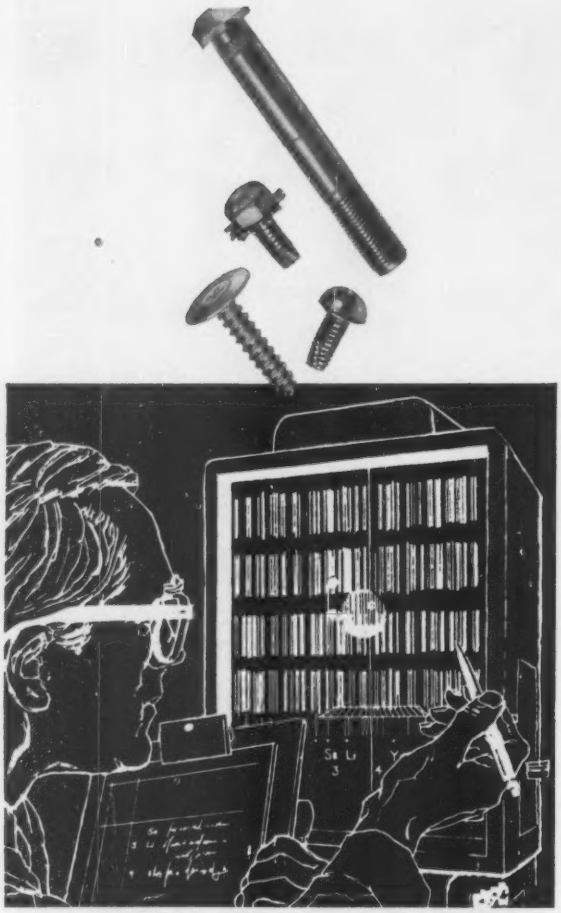

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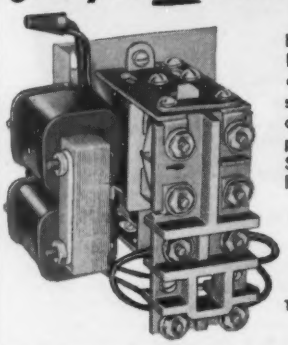

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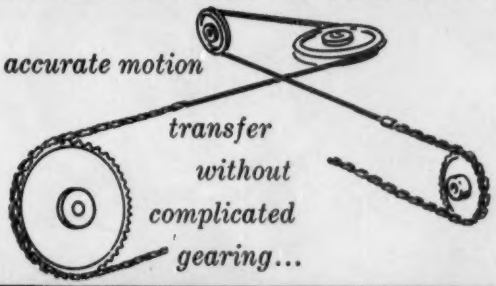

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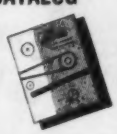

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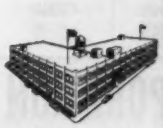

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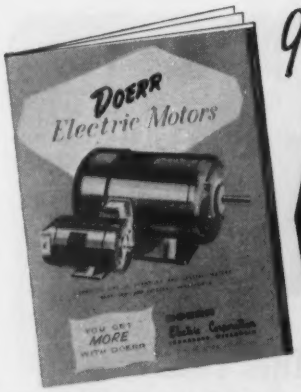

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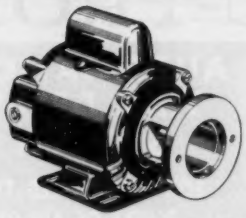

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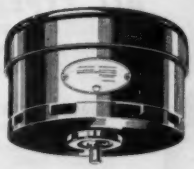

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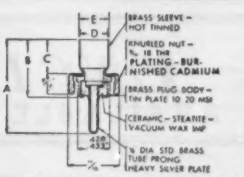
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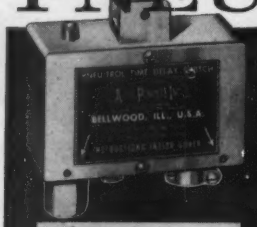
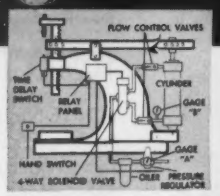
PNEU-TROL



AUTOMATION TIME DELAY SWITCH

FOR CONTROLLED TIME DWELL OF AIR OR HYDRAULIC CYLINDERS



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- **Automatically re-sets**
- **Designed for millions of actuations**

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BPA NBP

backtalk——

—With Gnashing of Teeth

"Your cover illustration for the January 7 issue of MACHINE DESIGN," reads a recent fan letter, "has set mechanical engineering back for years with its inside-outside gears rampant on a field of red." This unusual conception of gears may or may not have distressed other readers, but being loyal Farnsworthphiles, we will defend George's right to draw gears "inside-outside" any time he sees them that way.

Close scrutiny of the cover reveals that—far from setting mechanical engineering back—it has scored a sort of breakthrough. The involute curve on the ring gear teeth is not the one you would normally expect, yet George has managed to make these teeth mesh beautifully with those on the planetary gear.

—Auld Acquaintance

Expansion of MACHINE DESIGN's editorial staff has made the introduction of new editors a fairly regular feature of this page, a situation which generated the idea of dusting off the not-brand-new editors and giving you a look at them too. We begin with the gentleman whose picture appears regularly on our editorial page.

Colin Carmichael, a Scottish import, was born in Glasgow, graduated from that city's university with a B. Sc. in mechanical engineering, and soon after headed west to the United States. He arrived in 1929, shook the heather out of his slide-rule holster, and set to work designing marine diesel engines for Sun Shipbuilding and Dry Dock Co. in Chester, Pa. He then taught mechanical engineering and machine design at the University of North Carolina and Cornell, respectively, and climaxed his academic career at Rutgers, where he had charge of machine design courses.

Colin joined MACHINE DESIGN in 1942 as an associate editor; he was made editor in 1949. During the early days of his term here he also took on the editing of the design and production volume of *Kent's Mechanical Engineers' Handbook*. In 1950 he served as chairman of the Machine Design Div. of ASME, and last year was president of the Society of Business Magazine Editors. He is also a member of the scientific advisory council for Picatinny Arsenal.

A believer in the no play equals dull boy doctrine, Colin is currently off on a five-week European vacation. He'll visit a half-dozen countries besides Scotland and will have a busman's holiday at the Engineering Materials and Design Exhibition and Conference being held in London.

—Hot (or Cold) Jewelry

Style note for the engineer who has everything, including a working slide-rule tie clasp: An outfit in New York is now selling thermometer tie clasps and cuff links. Dials are calibrated from −20 to 120 F, and the instruments are sensitive to within 1 degree.

—Week After Next...

If you've got to get organized and can wait two weeks, an article in our next issue will prove helpful. This article discusses engineering projects and their three stages: Concept, design and manufacturing, and testing and completion. The two classic types of organization —project and functional—don't always fit all stages of development, so George Fried of AMF suggests and outlines an elastic "Convertible Engineering Organization."

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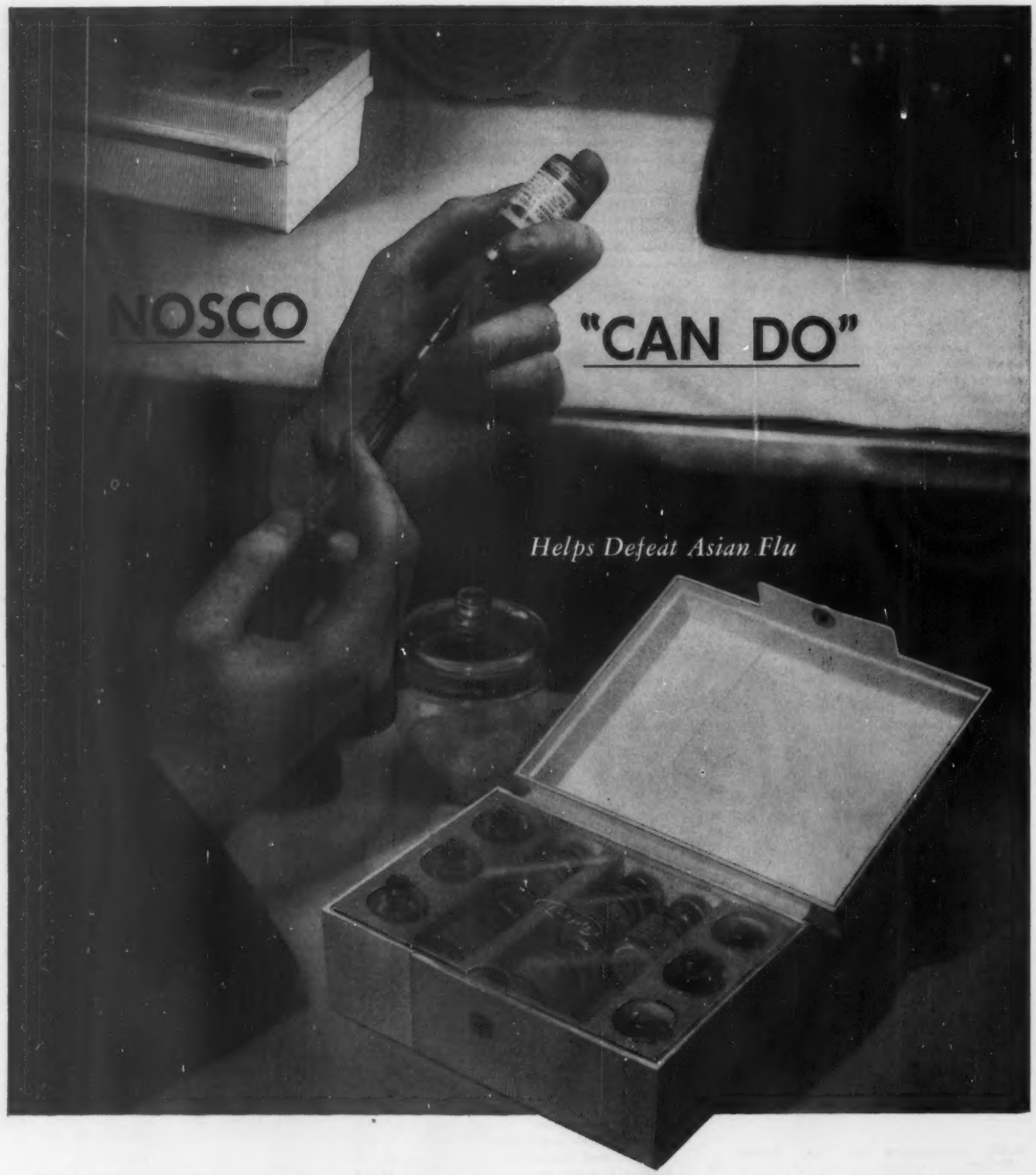

Yes, Nosco's famous "Can Do" ingenuity is contributing to a healthier America. Where doctors are fighting Asian Flu, you'll find this custom-molded Nosco Biological Kit by their side.

Lederle Laboratories wanted to make their precious flu vaccine easier for doctors to preserve and transport. They came to Nosco with their special requirements for a multi-vial carrying case. The container had to demonstrate striking clinical cleanliness and easy washability. Great shock resistance and chemical inertness were also necessary. And cost was important.

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cost-wise designers specify

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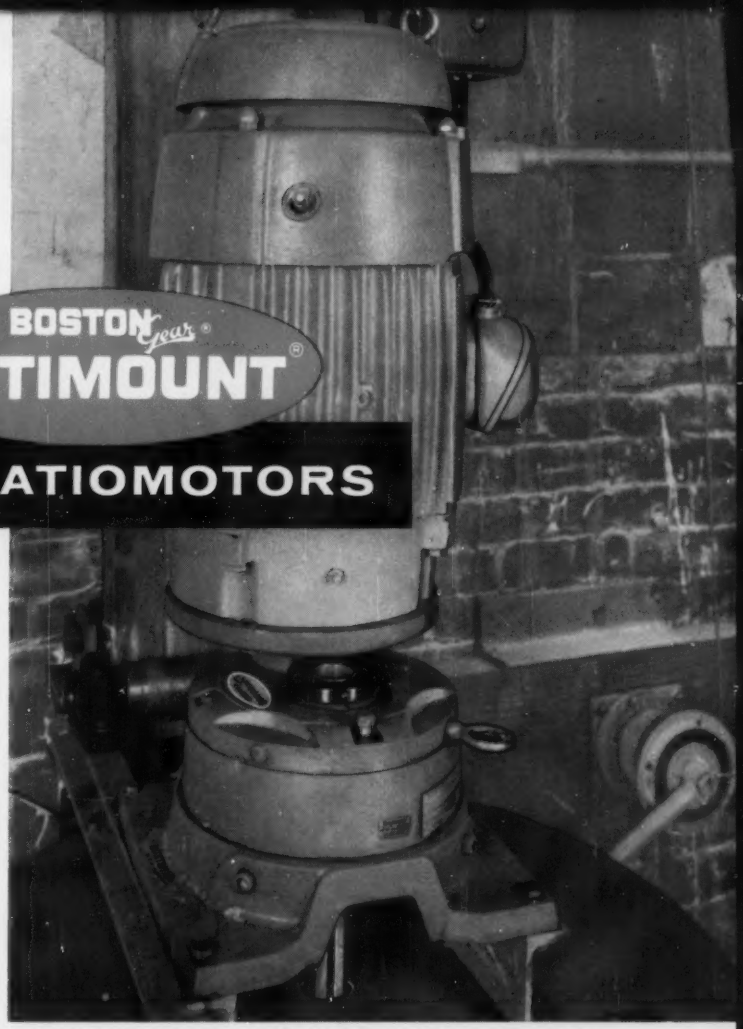
HELICAL GEARED RATIOMOTORS



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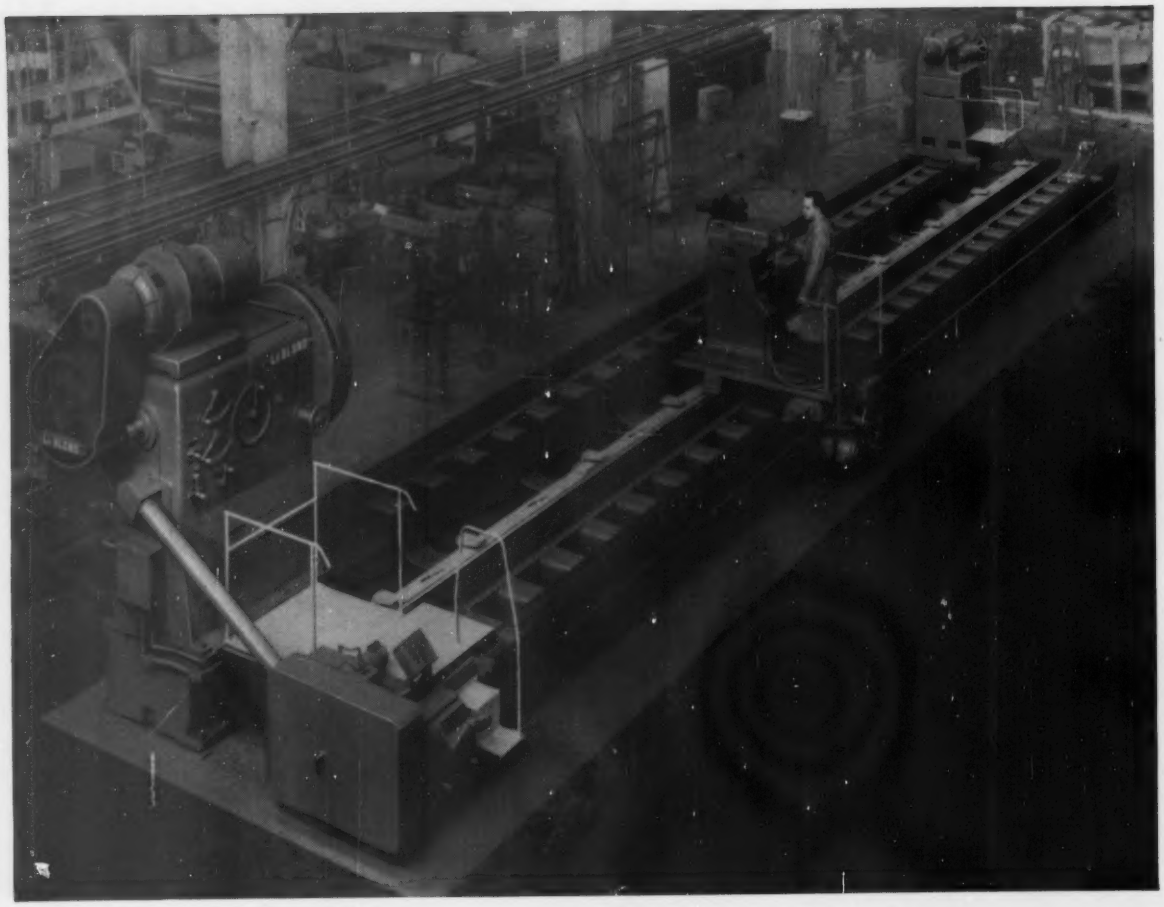

First U.S. double-bed lathe... Le Blond's huge "Admiral"... assures spindle rigidity with Timken® bearings

IT'S a giant!... this lathe built by R.K. Le Blond Machine Tool Co. Named the "Admiral", it's the first U.S.-built double-bed lathe. And it weighs 75 tons, is 54 ft. 6 in. long, 120 in. wide. To maintain spindle rigidity under 50,000 lb. line load, Le Blond mounts it on Timken® tapered roller bearings. And for extra quality, the lathe ways are made of Timken 91140 steel. Le Blond uses Timken bearings to get:

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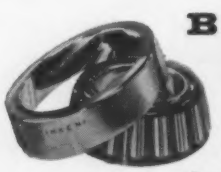

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